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SPECIAL ACCOUNTS

summing up the reports of the questions for discussion at the ninth congress of the International Railway Association (Rome, 1922).

SECTION I. — WAY AND WORKS.

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QUESTION I

(Construction of the road-bed and of the track),

By Mr. HENRY, special reporter.

The present note sums up the five reports received :

Report No. 1, by Mr. Mudge (1), and report No. 3, by Mr. Ewing (2) for America;

Report No. 2 (with a supplement), by Messrs. Henry and Candelier (3) for all countries other than America, Great Britain, Denmark, Sweden and Norway;

Report No. 4, by Mr. Ahlberg (4) for Denmark, Sweden, and Norway;

Report No. 5, by Mr. Trench (5) for Great Britain.

All these reports deal more particularly with the recent improvements that have been introduced into the construction of the road-bed and track by the engineers of the various countries in order to meet the increased stresses due, on the one hand to increased speed, and, on the other hand to the increased weight, per axle and per train.

In addition some engineers have added their conclusions regarding the best arrangements to be adopted in the construction of new lines.

INCREASED SPEEDS. — All the reporters are in agreement that the maximum speeds of the trains have not increased appreciably in the course of the last ten years, and they recognize the fact that these maximum speeds have reached the limit compatible with safety under the existing conditions of construction of the lines.

(1) See *Bulletin of the International Railway Congress*, August 1914, p. 713.

(2) See *Bulletin of the International Railway Association*, July 1921, p. 835.

(3) See *Bulletin of the International Railway Association*, January 1922, p. 251.

(4) See *Bulletin of the International Railway Association*, September 1921, p. 1147.

(5) See *Bulletin of the International Railway Association*, August 1921, p. 991.

In Great Britain and America 129 km. (80 miles) per hour appears to be the maximum speed for passenger trains; in Denmark and Sweden it is 90 km. (56 miles) per hour, in Norway it is 60 km. (37.3 miles) per hour and in France it is 120 km. (74.5 miles) per hour.

But passenger trains have become heavier and more frequent. The speed of goods trains has been increased to a maximum of 72 km. (45 miles) per hour in America, and some of these trains, particularly those carrying minerals, are made up of large-capacity wagons the weight of which loaded may amount to 60 tons.

INCREASE IN WEIGHT. — Heavy passenger-trains commonly weigh up to 400 or 500 tons; goods-trains from 1 000 to 1 500 tons, and this latter figure is sometimes even doubled.

The maximum loads on locomotive driving-axles are :

Scandinavia . .	17.5 tons.
France	18 tons.
Great Britain . .	20 tons.
America . . .	27.6 tons (passenger). 30 to 34.3 tons (goods).

The English state that although the maximum loads on driving axles have not been altered during the last ten years, the total weight of locomotives has increased by 25 %, and now reaches from 110 to 125 tons.

A. — Road-bed.

In the United States the figures given above appear to be the final limit, because it is not possible to increase the size of the locomotive further without going outside the loading gauge and causing difficulties on bridges, in tunnels, etc.

In the first place it is necessary to construct a sufficiently strong road-bed; and in the second place to take the necessary measures for ensuring uniform distribution of the pressures and dynamic forces exerted by the trains.

The first condition relates more particularly to questions of running off water, draining and keeping dry, and the second condition relates to the number of sleepers, the quality and the thickness of the ballast.

IN CUTTINGS. — *The road-bed proper.* — On *bad ground* it is necessary to drain the road-bed in order to give it proper strength and to arrange longitudinal drains to get rid of the water. This drainage is in some cases limited to a single drain in the centre of the track; but it is more usual to place drains on each side of the line, which enables the water that runs out from under each bank to be collected and prevents it making the road-bed soft.

It is also necessary to ensure adequate drainage for the surface water by means of lateral ditches or drains.

The arrangement of lateral ditches should be designed with the greatest care. It is necessary that these ditches should be deep enough to take the water from the road-bed which is led down drains, at an inclination of 4 to 5 %, into the ditches; it is also necessary that the ditches should be given sufficient longitudinal fall.

The ditches are usually of brickwork, which on the one hand enables the longitudinal fall to be reduced and, on the other hand, enables the road-bed bank, and also the foot of the cutting, to be better supported.

If a covered drain is arranged on each side of the track for getting rid of the surface-water (as is frequently done in America) these drains must be arranged with numerous inspection pits to enable them to be cleaned easily and rapidly.

In any case it is necessary to keep the top of the road-bed at such a level that it is possible to arrange a considerable thickness of ballast and under-ballast

(a lower layer, which usually consists of sand or locomotive ashes) between the road-bed and the under-side of the sleeper; it will be seen below that the total thickness of the ballast and of the under-ballast may amount to and may even exceed 0.60 m. (2 feet). On existing lines this frequently necessitates cleaning the surface of the top of the road-bed (by freeing from clay).

In dealing with particularly bad road-beds, these are covered with a casing of concrete (carapace) which is sometimes reinforced. Mr. Mudge (America) mentions casings of reinforced concrete 0.20 to 0.38 m. (8 to 15 inches) in thickness, the top of which is arranged 0.20 m. (8 inches) below the under-side of the sleeper; Messrs. Henry and Candelier (France) give a thickness to this casing of 0.20 m. (8 inches) (in ordinary concrete) and advise that the top of the casing should be arranged about 0.40 (16 inches) below the under-side of the sleeper.

This is a very efficient solution of the question, but very costly, and recourse should only be had to it under very exceptional circumstances.

If the road-bed is only of *medium* quality, the arrangements described above will only be applied in part. In particular it should be possible to economize on the drains, the ditches being adequate for receiving the water; it should also be possible to reduce the thickness of the layers of ballast and under-ballast.

With road-beds of *ordinary ground*, this total thickness of ballast and under-ballast should not be reduced below 0.30 m. (12 inches) of which at least one-half should be the ballast proper.

The width of the road-bed between ditches varies :

On single track, from 5.40 to 5.60 m. (17 ft. 9 in. to 18 ft. 4 in.) in Scandinavian countries, increasing to 6 m. (19 ft. 8 in.) in France and 6.10 m. (20 feet) in America.

On double tracks it is 9.40 m. (30 ft. 10 in.) in England increasing to 9.60 m. (31 ft. 6 in.) in France and 10 m. (32 ft. 10 in.) in America.

There is a tendency to increase these widths in order to enable a sufficient thickness to be given to the ballast and to the under-ballast. With a view to reducing the width of the road-bed it is possible to build dwarf brickwork walls to retain the layer of under-ballast.

In cuttings. — It may occur that the bottom of a cutting becomes forced upwards owing to the softening of the upper layers of the ground. This is avoided by a covering of earth and vegetation or by surface drainage (Mr. Mudge's report mentions surface drains at 45° in the slopes).

In deep cuttings these surface drains may be formed by a series of small arches adjacent to each other or superposed on each other, which cut up the slope and form in reality a series of small separate slopes on which movement of surface of the ground is less likely to occur.

It is also possible for more serious slips to take place owing to the sliding of considerable masses of earth. In this case the moving mass is removed and it is replaced by an embankment of good material, after the whole of the slope has been consolidated by means of ordinary drains and auxiliary drains reaching below the plane of slipping, and solidly anchored to the road-bed at the foot of the slope.

In some cases recourse is had to ring drains arranged at a distance of several metres behind the top edge of the bank, parallel to this edge, intended to catch subterranean water and prevent it from reaching the slope. In France this was abandoned a number of years ago, be-

cause a number of these drains which had become blocked in course of time suddenly caused serious sliding; the remedy in this case was worse than the disease.

On embankments. — When the ground on which it is intended to place an embankment is full of water, this should be drained off. If it is impossible to get the water away, good results may be obtained by arranging a substructure of rough logs and faggots packed alongside each other, known in America as « Corduroy » (Mr. Mudge's report).

The English and Swedish reports mention the same kind of foundation.

If the sub-soil is loose, it must be made compact by ramming after the upper layer (which is generally the stronger) has been removed to facilitate the ramming (Mr. Ahlberg's report).

Sometimes the ground at the sides of the embankment has spoil place on it to avoid upward displacement; this amounts in fact to increasing the base of the embankment (Mr. Ahlberg's report).

The embankment as far as possible should be made of good material, even when this can only be done at the expense of disturbing the balance between the volumes of cutting and embankment. If good material is not available in sufficient quantity it must at least be used for the upper part of the embankment and for the surface of the slopes. In such case the poorer material from the adjacent cuttings is used as the central core, the top of which is sloped off transversely from the centre, the inclines being from 15 to 20 %.

Some engineers advise that the central core should be covered with a coating of impermeable earth (loam) which stops the water. On this covering is placed the good material from the cutting, the lower layer of which should consist of small stuff, the larger stones, which would be liable to reach the central core, not being used as they might allow water to get through.

When abnormal settling occurs in embankments, it is generally due to water-pockets which it is necessary to drain.

If slips occur they are treated by similar methods to those which have been described above for the foot of a cutting slope.

An essential point is that ditches at the foot of embankment slopes, when the embankment rests on inferior or bad ground, should not be of the open type; these ditches would actually close up and start slipping of the embankment. The water must be drained away by means of underground drains.

Subsidences. — In some mining districts (England and France) subsidences of the road-bed occur owing to underground workings.

The places at which these subsidences are liable to occur are known, and should be subject to special supervision; supplies of light material should be arranged in advance in order to enable the level to be raised to the proper height.

In some cases the sleepers of tracks have been laid on and bolted to longitudinals so as to make a solid structure of several rail-lengths.

B — Ballast.

On many lines, particularly in the Eastern States of North America and in France a mattress (also called « underballast ») is inserted between the road-bed and the ballast proper, on the one hand to protect the ballast from the pressure of clay and other material squeezed out of the road-bed, and on the other hand to protect the road-bed against the effect of heavy falls of rain, and further to cause a better distribution of the pressure transmitted by the sleepers to the road-bed.

This mattress most generally consists of locomotive ashes fine sand, and cinders. Its thickness varies from 0.15 to 0.40 m. (6 to 16 inches).

The total thickness of the ballast and of the under-ballast should be increased when the road-bed is less stable and when it is consequently necessary to obtain a more uniform distribution of the pressure. In America it is accepted that, under the most favourable conditions, this total thickness should be 12 inches (0.30 m.), and that under the worst conditions it should be equal to the distance from centre to centre of the sleepers, and that intermediate thicknesses are adopted for intermediate conditions. It is moreover admitted that this total thickness should be divided in approximately equal parts between the under ballast and the ballast proper: as extreme figures the thickness of these on good road-beds in 0.15 m. (6 inches) for under-ballast and the same for the ballast; and on loamy road-beds of lines carrying heavy traffic 0.30 m. and 0.45 m. (12 and 18 inches) respectively. In France rather greater total thicknesses are used the under-ballast or mattress being of greater thickness.

The quality of the ballast depends on local conditions. The preference is generally given to hard stone (trap), to blast-furnace slag, and to gravel. In some parts of America burnt clay is also used successfully, and on some French lines sharp sand (called in French *claine)* obtained by running blast-furnace slag into water.

Stone should be broken to go through a ring about 0.06 m. (2.36 inches) in diameter.

With regard to gravel this should contain a proportion of sand, from 20 to 25 %, in order that it may not be displaced too easily. The large pebbles contained in it should be broken to pass through the 2.36 inch gauge.

When the ballast of a track is being renewed, care should be taken to remove only the layer mixed with mud which generally is not more than 0.08 m. to 0.10 m. (3 to 4 inches) below the sleeper. The remainder of the old ballast is kept for the under-ballast or mattress.

C. — Track.

Rails. — The unanimous opinion of the European reporters is that there is no advantage in increasing the weight of the rail beyond 47 to 50 kgr. per m. (94.7 to 100.8 lb. per yard).

In America, in 1908, two types of heavy rail were tried, the one weighing 44.6 kgr. and the other 49.6 kgr. per m. (89.9 lb. to 100 lb. per yard) which the « American Railway Association » ultimately adopted after an investigation into rail sections and the Association recommended these as the standard types.

Nevertheless some important American Companies have for the last five years put into service a sensibly heavier section weighing 64.5 kgr. per m. (130 lb. per yard) which, according to them, is alone capable of carrying very heavy traffic. This type of rail of which nearly 400 000 tons have already been used has the following advantages :

1° Fracture of the rails is comparatively rare;

2° On curves of short radius, the rail lasts two and a half times as long as the 49.6 kgr. per m. (100 lb. per yard) rail;

3° The carbon content of the steel for the rails can be raised from 0.69 % to 0.78 %.

In France, investigations of recent years have had for their special object the unification or standardization of rails used over the various railway systems.

These investigations have led to the adoption of two types for normal tracks: the 36 kgr. per m. (72.57 lb. per yard) type for ordinary tracks; the 46 kgr. per m. (92.73 lb. per yard) type for

tracks carrying heavy traffic. Finally, in order to meet the rapid wear of rails on underground railways, due to the action of smoke and moisture, a rail weighing 55 kgr. per m. (110.87 lb. per yard) has been adopted which differs from the 46 kgr. per m. (92.73 lb. per yard) type only in that an extra thickness of 5 mm. (0.2 inch) is given to the head and to the foot.

The length of the rail varies from 12 to 18 m. (39 ft. 6 in. to 59 ft. 3 in.) and under exceptional conditions is as much as 24 m. (79 feet). An attempt is being made to reduce the number of rail-joints, but there is a limit to this caused by the difficulties of transport to the spot, in putting the rails into place, and in replacing them.

The rails are usually laid with joints opposite each other, but sometimes they are laid breaking joint.

The rail-joint is fitted with fish-plates and is supported either by two sleepers placed next to each other (Mr. Ahlberg's report) or by sleepers placed 0.42 to 0.45 m. (16 1/2 to 17 3/4 inches) from centre to centre.

Sleepers. — The reporters are unanimous in admitting the superiority of hard-wood sleepers for lines carrying heavy traffic; metallic sleepers have gained but little ground.

The widths usually given to wooden sleepers vary from 0.22 to 0.26 m. (8 3/4 to 10 1/4 inches) : the question as to whether they should be laid with the heart of the wood above or below is still a subject of controversy.

The length adopted for these wooden sleepers is 2.44 to 2.60 m. (8 feet to 8 ft. 6 3/8 in.) in America, from 2.60 to 2.70 m. (8 ft. 6 3/8 in, to 8 ft. 10 3/8 in.) in the Scandinavian countries, and from 2.55 to 2.60 m. (8 ft. 4 3/8 in. to 8 ft. 6 3/8 in.) in France.

In England, where a large number of soft-wood sleepers are used, the general length before the war was 2.74 m. (9 feet). For the last few years in consequence of the shortage of timber a great number of sleepers have been laid measuring 2.59 m. (8 ft. 6 in.); these have stood well and it is possible that this length will be generally adopted.

It is usual to lay from 1 1/4 to 1 1/2 sleepers per metre run of rail (0.80 m. to 0.67 m.; 2 ft. 7 1/2 in. to 2 ft. 2 3/8 in. pitch) : the latter is the pitch suitable for inferior or bad road-beds.

The mechanical packing of sleepers has made but little progress. On the other hand certain Companies in England and in France have replaced ordinary-packing by shovel-packing; the sleeper is lifted and the surface raised by the insertion of a layer of sharp sand of very good quality by means of a shovel on the bed of the ballast.

Fish-plates. — In those countries that use the double-headed rail carried in chairs, the fish-plate most in use is of short length 0.46 m. (18 inches) with 4 bolts : it is of shallow depth and fits the space between the heads of the rail.

The fish-plates used with the flat-bottomed (Vignoles) rail are of various types; the 6-bolt type is being gradually replaced by the 4-bolt type. The use of fish-plates with wings extending under the sole of the rail, if not abandoned, is at least not common.

In America angle-section fish-plates, strengthened at the head and base, have been in use for a few years; these fish-plates have great rigidity. It appears that their adoption has appreciably reduced the number of breakages of fish-plates.

CONCLUSIONS.

The conclusions arrived at in the various reports are fairly similar and they may be summed up as follows :

The maximum speeds have not been

subject to appreciable increase during the last ten years, but trains running at high speeds (passenger and goods) have become more frequent.

The weight of the trains and the weight of the locomotives have increased as also has the load per axle on goods wagons.

Road-bed. — The road-beds on some lines have suffered from these increases of load, and it has been necessary to take measures for distributing the load due to the trains more uniformly over these road-beds : by increasing the thickness of the ballast, the number of the sleepers and the weight of the rails.

It is advisable in the equipment of new lines to obtain a road-bed of sufficient strength and to distribute the loads over it as uniformly as possible.

The methods devised are the following :

On embankments. — Draining and drying the natural ground.

If this drying cannot be done without excessive cost, a mattress of wood and branches should be arranged in order to distribute the loads on the sub-soil uniformly and to facilitate the uniform settling of the embankment.

If the sub-soil is very compressible, the width of the base of the embankment should be increased.

As far as possible embankments should be made of good material, or at any rate this should be the case for the upper portion. If the central core of an embankment is of clayey earth, arrangements should be made to prevent surface-water from reaching the core.

In cuttings. — Draining the road-bed and keeping it dry if it is bad.

Maintaining a considerable thickness of ballast proper and of under-ballast between the road-bed and the under-side of the sleepers.

If the road-bed is particularly bad, covering it completely with a casing of concrete (reinforced or otherwise).

Providing for suitable drainage of surface water by means of lateral ditches or drains.

Ballast. — The total thickness of the ballast proper and of the under-ballast depends on the strength of the road-bed; it should vary from 0.30 to 0.60 m. (1 foot to 2 feet) to be divided between the two layers in suitable proportions.

The mattress or under-ballast, should consist of fine and permeable material which will allow the water to drain off, but which will not mix with the earth of the road-bed.

The selection of the proper ballast depends on local conditions. The best materials appear to be hard stone (trap) broken to go through a ring 0.06 m. (2.36 in.) in diameter, slag broken to the same gauge, and gravel mixed with 20 to 25 % of sand.

Sleepers. — Wooden sleepers (particularly those of hard-wood) retain their superiority over manufactured sleepers.

The most advantageous length appears to be 2.60 m. (8 ft. 6 3/8 in.).

Except in some special cases, on the average, in Europe, 1 1/2 sleepers per metre of length of track is not exceeded.

Rails. — In America the sections used on the greater part of the lines vary between 29.8 kgr. and 49.6 kgr. per m. (60 lb. and 100 lb. per yard). On some lines types varying from 49.6 kgr. to 64.5 kgr. per m. (100 lb. to 130 lb. per yard) have been in use for five years.

The most commonly used type in England weighs 47 kgr. per m. (94.7 lb. per yard).

In France, the Standard rails, recently adopted, are of two types: 36 kgr. per m.

(72.57 lb. per yard) for ordinary lines and 46 kgr. per m. (92.73 lb. per yard) for lines carrying heavy traffic.

Finally on some underground lines a section is used weighing 55 kgr. per m. (110.87 lb. per yard).

To sum up, the progress made during the last ten years appears to show the following features :

1° Increase in the thickness of the ballast by the addition of under-ballast or a mattress;

2° Increase in the number of sleepers;

3° A quite appreciable increase in the weight of the rails.

QUESTION II

(Maintenance and supervision of the track),

By EARL STIMSON, special reporter.

The scope of this question is given as covering measures to be taken to provide an economic organization for the maintenance and the supervision of track. In dealing with this subject the following elements affecting maintenance costs are required to be taken into consideration: the increase of traffic, the increase of speed, the rise in wages and the rise in the costs of materials. As a means of effecting economies the use of mechanical appliances is suggested.

Four reports are submitted on this question :

Report No. 1 for America, written in 1914, by Mr. Epes Randolph (1);

Report No. 2 for Great Britain, by Mr. Chas. J. Brown (2);

Report No. 3 for America, complementary to report No. 1, written in 1920, by the writer of this summary (3);

Report No. 4 for all countries except Great Britain and America, by Mr. G. Barbieri (4).

For convenience these reports will be referred to in this summary as, the 1914 American report, the 1920 American report, the British report and the other countries report.

Of the four elements to be considered as affecting maintenance costs, those most responsible for the great increase in these costs since 1900 are the rise in wages and the rise in the costs of materials. It may safely be stated that these costs have been but slightly affected by any increase in speed and only to an indeterminate degree by the increase of traffic. There has been increased demands on and refinements in track maintenance due to increase in traffic, speed and wheel loading. These have been met by a strengthening of the track structure by using heavier rail and fastenings, increasing the number of ties to the rail length, increased depth of ballast, etc. While this improvement in track structure is represented by an increase in costs, it is somewhat offset by a decrease in after maintenance on account of the greater stability of the track and its greater resistance to wear.

The American reports show that from 1900 to 1914 the average cost of normal maintenance of one mile of single track increased 40 %, due to an average increase in total wages paid of 45 %, and in cost of materials of 35 %. Of the 45 % increase in total wages paid per mile of track, 55 % was due to increased wages and 45 % to the increased number of men employed. This increase in the number of men employed was had, notwithstanding the fact that there had been

(1) See *Bulletin of the International Railway Association*, October 1920, p. 665.

(2) See *Bulletin of the International Railway Association*, June 1921, p. 663.

(3) See *Bulletin of the International Railway Association*, August 1921, p. 977.

(4) See *Bulletin of the International Railway Association*, January 1922, p. 139.

considerable improvement in track standards, increased weight of rail, increased ballast section, increase in size of ties and their number per mile of track and other like measures taken to increase the physical life and permanency of the track structure. This would indicate a decrease in the efficiency of track labor.

The increasing costs of material and rates of pay of labor reached the high point in 1920. These together with restrictive working conditions and a marked decrease in the productiveness of labor brought the cost of maintenance to a point more than 200 % above that of 1914 for equivalent accomplishment.

Note. — Since the 1920 report was written there has been a decrease both in wages and price of materials, which has materially decreased maintenance costs.

In giving the comparison of the cost of maintenance and renewal of the track with 1900 the British report states that with practically no exceptions there had been up to 1914 no variation as compared with 1900 in the number of men per mile of running line employed in the maintenance of the track owing to increase of traffic or greater speeds, this result being no doubt due to its greater strength; on several railways the number of men had been increased for ordinary maintenance purposes, the percentage in the maximum instance being 15. During this period advances in wages were granted fairly generally and caused the annual cost per mile of track maintained in respect to wages to go up to an extent varying from 6 to 30 % on British railways and from 6 to 40 % on Indian railways. Advances in the cost of materials during the same period were from 6 to over 50 % on British railways, from 8 to over 100 % on Indian railways and 10 % on the only Australian line reporting.

The corresponding comparison of 1900 with 1920 shows a great jump up in the figures for the latter year. The British lines in particular report additional men had been put on for ordinary maintenance purposes, largely due to the shortening of the working hours to 48 per week, the percentage of increase ranging from a small fraction of 1 to 13, with one exception which showed an increase of 48 %.

The great increases in wages and materials on the British railways brought about by abnormal conditions are clearly reflected in the figures for 1920 as compared with 1900, which show, for the railways making a return, a percentage increase in wages ranging from about 180 to 300 and for materials from about 130 to 300, the corresponding figures for the combined wages and materials being 178 and 300.

The British railways report the cost of labor relaying a mile of railway in 1914 varied from £160 to £470, representing a percentage of increased cost as compared with 1900 ranging from 7 to 30. By 1920 this cost had gone up from £405 to £1 200, the percentage of increased cost as compared with 1900 ranging from 180 to 387.

The figures furnished by the Indian, African and Australian railways tend to show that the cost of relaying increased in much the same percentage as the British railways up to 1914, but to a much less extent for the period from 1914 to 1920, the percentage figure for the latter year as compared with 1900 being only about 75. In New Zealand the corresponding increase is 97 1/2 % solely due to advance in wages.

The other countries report cites the fact of large increases in the costs of material and wages, varying with the conditions existing in the countries under consideration, but finds it difficult to differentiate between the effects of temporary conditions and those resulting from permanent causes, and impossible to make comparisons between mainten-

ance cost on the different railways and to compare present day costs with those ruling at the time of the last Congress.

All the reports agree as to the greatly increased costs of maintenance and as to the causes, and deal principally with means of effecting economies in organization and methods of work.

There follows a resume of the forms of organization, the methods of work and measures taken to effect economies and a statement of the conclusions given in the reports.

Organization of the supervisory staff.

On the British railways the department dealing with the maintenance of track is under the charge of the chief engineer. Under this officer are the district or divisional engineers, who have direct charge of the maintenance of districts or divisions, into which the road is divided, such districts or divisions averaging 250 miles of road and 832 of all tracks.

On smaller railways with track mileage of under 700 miles the engineer in charge of the department exercises direct supervision without the intervention of divisional engineers.

South African railway — the organization is somewhat different, being composed of three superintendents of maintenance, one in charge of 3 500 miles and two in charge of 2 500 miles each, with assistant superintendents under them.

On Australian railways the route and track mileage under divisional or district engineers varies widely, reaching a maximum of 1 342 miles and 1 438 miles respectively. Under the divisional or district engineer is a chief inspector who supervises the ordinary permanent way inspectors who have charge of a length of road of a maximum of 62 miles and an average of 37.

The Indian railway has inspectors' sections of from 80 to 100 miles in length, with assistant inspectors under the inspector, in charge of about 40 miles. On some railways there is no chief inspector, the inspectors reporting direct to the divisional or district engineer.

The other countries report states that as a general rule the Maintenance Department is organized as an independent department. The line is divided into divisions — divisions into sections and sections into sub-sections or districts.

The French Midi Company divides its lines into divisions and divisions into sub-divisions which are comparable to districts :

Average length of division from 310 to 800 miles;

Average length of sections from 37 to 165 miles;

Average length of sub-sections from 6 1/4 to 56 miles.

No modification of the organization has been made to offset the increase in salaries although two administrations have increased the length of some districts and the Italian State Railway is about to abolish some of its sections and put in districts directly under the control of the divisions.

The Swiss Federal Railways has considered the extension of its sections and districts.

The opinion is expressed that the best organization from a technical point of view is to divide the system into sections of a length equal to or even greater than 185 miles directly responsible to the chief of the department, and the sections divided into districts.

For railways of considerable length it is advisable that the Maintenance Department be quite separate from the other departments. It is not considered advantageous to have officials exclusively responsible for the Maintenance of the Track and other officials responsible for the other engineering work on the railway, etc., except in cases of work of exceptional importance requiring special experience.

Recommend special official to control the handling of temporary labor, use of new material, sorting of material taken out of service and the economic use of that not scrap.

The American report gives two forms of organization, the departmental and the divisional, the divisional predominating.

The essential difference between the two forms of organization is the manner of maintaining contact between the head of the department and the officer in direct charge of the department on the division. Under the divisional organization this contact is maintained through the general superintendent and the superintendent, both largely transmitting mediums, and under the departmental organization the contact is direct.

The 1914 American report recommends the « Divisional », whereas the 1920 American report recommends the « Departmental » form of organization.

For maintenance purposes the system is divided into divisions in charge of a division engineer, — the divisions into districts in charge of a track supervisor, — the districts into sections in charge of a section foreman. The length of divisions range from a minimum of 100 to a maximum of 700 route miles and 235 to 1 800 miles of all tracks.

Supervisor's districts range from a minimum of 55 miles (and even less) to a maximum of 150 route miles and 85 to 170 miles of all tracks.

Organization of the working forces.

The American track section varies in length greatly from 2 to 12 route miles. There is recommended for average traffic roads a length of 8 miles of running track and a reduction made in this mileage on the basis of 5 miles of sidings and fifteen switches being equivalent each to 1 mile of running track.

The length of some track sections on a number of roads has been increased and consequently the number of sections reduced, eliminating a corresponding number of foremen, by the introduction of gasoline driven motor cars, replacing hand driven cars for transporting the men to and from their work. The increased length of the section being somewhat relative to the increased speed of the « motor cars » as compared with the « hand cars ». The economies effected by the use of the motor cars are the saving in foremen where sections are lengthened, the saving in time going to and from work account the greater speed of the motor cars and the increased efficiency of the men by conserving their energies for their actual track labors. All these economies are, however, to some extent offset by the cost of the operation and maintenance of the motor cars which is no inconsiderable item.

On the British railways the equivalent for the American « section » is the « length » varying from 1 to 4 miles. On the Indian Railway the « length » varies from 3 to 5 miles, with an average number of men per mile of 2.5; on the South African Railways the length runs from 3 1/2 to 20 miles with an average of one man per mile; the Australian Railways from 6 to 8 miles, average number of men 0.5 per mile; and the New Zealand Railways the average length is 6.85 miles and the average number of men per mile is 1.65.

These figures are exclusive of the men in relaying gangs where such are employed.

On the Italian State Railways the « lengths » are equivalent to 2 1/2 to 7 1/2 miles of single line and the number of men in the gangs varies from 2 to 10 in addition to the gauger (foreman). An inspector (general foreman) has control of a group of gangs (up to five). A number of railways exceed these limits of length and number of men, for example, the Swiss Federal Railways have lengths ranging from 11 to 19 miles. The prac-

tice seems quite common to the railways of all countries to have as a permanent force the men comprising the « section » or « length » gangs, the number of men varying with the seasonal demands. These gangs perform the current maintenance work, light renewals and inspect and patrol the roadway and track.

The heavy seasonal work and any special work, such as rail renewals, resurfacing, re-ballasting, ditching, etc., is performed by « special » « temporary » or « extra » gangs organized for the purpose and disbanded on completion of the work.

These extra gangs usually vary in number of men from 20 to 50, in charge of a foreman and in the case of the larger gangs an assistant foreman in addition. A gang of about 30 men under a foreman and an assistant foreman appears to be the economic maximum size for gangs for single operations such as rail laying, ballasting, tie renewals, etc. When these operations are carried on simultaneously a combination or « grouping » of separate gangs for each operation under a general foreman is recommended.

The withdrawal of the regular « section » or « length » men from their own sections to make up these extra or special gangs for relaying work, is not recommended as the best practice, except in cases of emergency and perhaps in cases of the less important and light traffic branch lines.

Track inspection.

While the systems of track inspection described in the reports vary considerably in detail, there is provided by all an inspection of the track by an assigned member of the « section » or « length » gang or a *garde-route* (a special employee). These inspections vary in frequency from twice a day for important, dense traffic lines to once every two or three days for light traffic branch lines where conditions are normal and on which there is no possibility of land slips, falling rocks, etc.

The report for Great Britain states that the inspectors are required to make a periodical inspection of the track with a frequency varying from once in three months as one extreme to twice a week as the other extreme. Once a week seems to be the average requirement.

The report for America indicates that the supervisors or roadmasters who correspond to the « inspectors » make an inspection of a part of their districts each week and by so doing cover their entire district at least three times a month. Unless the supervisor's district is quite restricted in extent he would hardly be able to inspect in detail his track oftener than once a month and have time for the proper pursuit of his other duties, as both the reports for Great Britain and America agree that this inspection should be made either afoot or on velocipede or motor cars (trolleys).

It is specially stated that the inspections from the rear end of trains or seat in the train should not be considered « sufficient » and are « quite useless for the purpose ».

According to the report for America the section foreman is required to inspect his entire section at least once each week and the « track walker », who is part of the section force reporting to the section foreman, patrols the track daily, making such minor repairs to the track as he can with the tools carried by him and reporting to the « section » foreman any repairs requiring the attention of the « section » gang.

The British report indicates that on British railways the length gauger (section foreman) or a length man (section man) examines the track twice a day, except Saturday, when one inspection is made, and Sundays when one is made on lines on which passenger trains are

run on that day. On the Indian, African and Australian railways the line is examined once a day and on the New Zealand Railway the gaugers (foremen) are required to examine their lengths personally once a week but in actual practice in these as in all cases the track is at least inspected in part daily by the foremen and men as they go to work.

In the other countries report it is stated : 1° some administrations follow a practice similar to that outlined above; 2° others use the level crossing keepers (grade crossing watchmen) for inspecting the track, and 3° others use special employees, road guards (*gardes-routes*) to make this inspection. The road guards are responsible for the inspection of lengths of track of from 8 to 10 miles and are allowed to return home by train after completing their inspection. The report expresses preference for the third method as the most economical, as admitting of longer lengths to be inspected than when done under the first and second methods, and effects further economies if at the same time the level crossing keepers are abolished. Economy in personnel is suggested by reducing the frequency of inspections.

Methods of carrying out renewal work.

. The method of general relaying of the track, that is, relaying by complete removal of the old track and replacement by new materials, seems to be almost general practice on the British Railways and on those railways covered by the other countries report. The argument supporting this method is that the result will be a track in perfect condition allowing the periods between general relaying to be increased and meantime cutting down the minor maintenance repairs.

While the American reports do not touch on this point, the controversy over the merits of « out of face » work and « spot » work is a live one. It is considered good practice to follow the relaying of the rail with the tie renewals, at the same time respacing the ties to uniform distances apart, raising the track, resurfacing and replenishing the ballast.

Some roads, in carrying out tie renewals and surfacing, work over a given number of miles of a section each year raising the track « out of face » (giving it a uniform lift throughout), renewing all ties which would need renewal within the next several years, replenishing the ballast, dressing up the roadbed and putting the track in such condition as not to need much attention for two or three years, during which time the other miles of the section are being similarly worked. This method gives good results where carried out consistently and where favorable maintenance conditions prevail.

Other roads work over the entire section each year, renewing only what ties require renewal at the time and surfacing or raising the track only where existing irregularities demand. This is the « spot » method and answers well for light traffic lines, but for heavy traffic lines does not give as good results, nor permit the attaining of as high a standard of maintenance. This is, however, the expedient to which roads of limited resources are compelled to resort.

In the other countries report a system of applying ballast known as « soufflage » is described and recommended. This system is peculiar to railways dealt with in that report.

Track maintenance by contract.

There appears in all the reports more or less mention of applying the contract system to track maintenance. This gives evidence that this system is being seriously considered as a possible means of effecting economy. In fact at the present writing this matter is of considerable importance, for if the system proves truly economical under the prevailing

conditions and is widely followed, it will have a revolutionary effect on the maintenance organization.

As to the extent to which this contract system has been used, only one British company reports having employed contractors and now abandoned the practice. Three cases are reported on the Indian railways where contractors are employed for labor only.

In the other countries report a more extended use of the contract system is mentioned. Contractors are employed by some administrations only for special work such as cleaning the ballast and complete relaying of the track, similarly the French Eastern Railway contract the renewal of ballast and re-ballasting the track, and the Italian State, the Belgian State, the Portuguese State railways have tried the same system. The Italian State railways have made their experiment on a large scale choosing « lengths » of various conditions of layout and traffic. They have employed either small contractors or co-operative societies of workmen, who work with ordinary tools over a length of 6 1/4 miles, or a contractor over long « lengths » of about 53 miles of track, using Collet's patent machines. The results are reported as not altogether favorable.

None of the administrations have considered doing the work of relaying by ordinary gangs on the piece work system.

The other countries report also states that the system of contracting the general relaying appears to be in little favor with the administrations. The opinion, however, is expressed that with proper supervision as good results should be obtained by the contractor system as by work done directly by the administrations. This is based on the assumption that the present day output of workmen, particularly those employed on the regular staff of the State Administrations, does not correspond with the large increase in wages, and that only the direct and interested supervision of a contractor can overcome this tendency and obtain greater activity and more efficient methods. It is also stated that workmen who seek employment with contractors more readily accept lower wages than those employed by the large State or private administrations and accept piece work instead of day work.

The 1914 American report discusses the subject of maintenance by contract or piece work but cites no instances of the application of such methods. Doubt is expressed whether track maintenance in whole or in any great part can with ultimate economy be accomplished by the « piece work » system. On certain classes of work, such as moving right of way, the handling of track, bridge and building materials, when a unit of measure (acre, piece or ton) can be readily established and on which no risk or refinement is involved in its performance, contracting by piece work can successfully and profitably be done. However, for actual work on the track, done under traffic, such as rail and tie renewals, ballasting, lining and surfacing track, such a system cannot be recommended as a measure towards economy. This for the reason that permanency, lasting stability and safety are factors of first and most important consideration and with these the contractor has no responsibility or little interest, as his interest lies in quantity of performance in terms of feet of rail laid, yards of ballast placed or other units. With the passing of inspection the contractors' responsibilities cease, whereas with work performed by railroad company forces under regularly employed foremen there is a personal responsibility for future, subsequent and consequent results, which influences towards quality, rather than quantity performance. Even if this quality is obtained at greater first cost than under the contract piece work system, the opinion is expressed that, in the final analysis, it is the more economical.

This point has been presented the more fully as there is quite a wide variance in its treatment in the American report and the other countries report.

The « piece work » or « unit price » system of contracting track work has been used to a limited extent on American roads. Within the past few years (since 1917) the « force account » or « cost plus a percentage » system of contracting track work has been somewhat extensively used. This system was first resorted to in a time of intense industrial activity and consequent labor shortage and high wages. The contract on this basis admitted of greater flexibility of organization and of scale of wages, than was possible under the direct handling of the railroad. Under this system the supervision was usually furnished by the railroad company and the work done under its direction. The work was not economically done under this system. On the subject of contracting track work which so vitally affects the maintenance organization there seems room for a good argument, as the other countries report favors contracting track work, while both the report for Great Britain and that for America are directly against it.

Mechanical appliances and equipment for maintenance work.

The reports seem a unit in agreeing on the desirability of introducing labor saving devices and the further applying of those already in use.

The British report and the 1914 American report refer at length and illustrate with figures cars especially designed for the handling of ballast and unloading it on the line. The car illustrated in the American report is one in common use on many railroads. It is designed so that it may be used for both « center » and « side dumping ». The sides of one car are hinged so as to open outwards and the floor of the car is hinged longitudinally, opening from the center back against the sides. With the hinged floor down, the car is a flat bottom car and may be used for side dumping by opening the hinged sides. For side unloading, a plow either plowing off to both sides or to one side only, is dragged over the cars from one end of the train to the other by a cable from a winding engine with a large diameter drum on a car next to the engine and operated by steam from the engine. For center unloading the hinged sections of the bottom are thrown back against the sides and form an extension to the sides of the hopper below the floor. With the hopper open the ballast is unloaded in the center of the track. The cars are of a capacity of from 40 to 50 tons and can be used for commercial loadings. These cars are similar to the cars described in the British report and shown as figures 5 and 6, and figure 9 when fixed for « center dumping », and are somewhat similar to the car shown as figure 12, when fixed for « side dumping ». On American roads a ballast plow, for spreading the ballast after unloading, similar to that shown as figure 10, in the British report, is used quite extensively, particularly with gravel ballast.

The noteworthy difference between the British and the American cars is the much greater capacity of the American cars (twice the capacity of the largest British cars) and the American cars are so designed and built as to be readily converted into cars suitable for general commercial use.

The British report shows special cars for the handling of sleepers (ties) and rails, which are essentially the same as the American « flat car ». A notable « special » wagon for the handling of heavy chained sleepers, is the Great Western type of crocodile wagon, figure 17.

The other countries report does not go into this matter in detail, but states that experiments have been made in the

use of special wagons to carry ballast and to discharge it rapidly along the line.

There is no doubt that large economies are had in the handling of ballast by the use of this special equipment.

The use of power machines for ditching the roadway, cleaning out cuts, for loading and unloading materials in storage yards and on the line of road, is mentioned in the 1914 American report. A machine designed to serve such a combination purpose and termed a « Ditching and General Utility Crane » or « Steam Ditcher », is in general use on American roads. Such a machine is illustrated by figure 5 in the report. The flexibility of this machine is great and it can be adapted with great economy in man power, to a variety of uses. Used for ditching or cut widening in connection with dump cars operated by air, and a spreader car to spread the material dumped, clear of the roadbed, this machine effects large saving in man power and money.

Steam cranes are mentioned in the British report as being used for laying in junction and crossing work which has been built up complete alongside. On some American roads a steam locomotive crane forms part of the work equipment of each supervisor, and is used not only for loading and unloading heavy materials, but in laying rail. The crane picks up the rail, which previously has been unloaded along the track, and places it in position on the ties, gangs preceding the crane uncoupling the rail, throwing it out and preparing the ties for the new rail and other gangs following, spiking up the rail, applying the joint fixtures, etc. By this method, which requires a large force of men to keep up with the pace set by the crane, some remarkable records of rail laying have been made. This method requires the abandonment of the track for traffic and is therefore only applicable to a multiple track railway.

Travelling steam or electric cranes are reported as used in a number of cases as handling plants in the material depots for handling heavy stores like timber, rail, etc., and effecting quite appreciable economy in the number of men required. For the lighter work a number of machines are reported as being used with good results, among which may be mentioned, machines for boring sleepers or ties for screw spikes, for tightening bolts and screws, track drills, rail and timber tongs, rail saws, track jacks, special gauges and appliances for the more expeditious handling of rails during relaying, such as shown in the British report as « rail remover and layer » and a « pick-up and sorter ». These last appear to be ingenious « home-made » affairs, having a counterpart in a more elaborate « manufactured » device in use on many American roads.

The British report mentions at some length the use of the plate layers « shovel packer », illustrated by figure 4 of that report, in place of the usual beater or shovel for packing sleepers. A lessening of the amount of ballast to be handled and an easing of the labor of packing is claimed for this device.

All of the reports mention the pneumatic or electric power appliances for packing, tamping or ramming the ballast under the sleepers or ties. The British report states one or two railways have experimented with this appliance but that so far the trials have not been particularly promising, as the apparatus used proved awkward to handle on a busy line, and the results did not go to show that economy was likely to be effected under the present system of organization of the maintenance gangs.

The other countries report expresses the opinion that even in the hands of the ordinary gangs the ballast ramming machines may prove advantageous both from a technical and economical point of view. The report further states that the compressed air rammers have the disadvantage of the noise caused by the

exhaust of the air, requiring careful protection, by danger signals, of the scene of operations. According to this report, based on the personal experience of the reporter, the sleepers can be packed better by machine than by hand, and the ballast is less broken up.

The experience with the pneumatic tie tampers on the American railways, which in some instances has been extensive, fully confirms the conclusion of the other countries report, and indicates beyond a doubt that it is an economical device, a great labor saver and does mechanically much better, more uniform and more permanent work than can be done by hand. This matter of the use of mechanical appliances in maintenance work is one of increasing importance in getting economic results. For that reason it has here been dealt with at some length. The practical maintenance man (the supervisor or inspector of track and the foreman) is inherently conservative and slow to take up new devices. This together with the heretofore low wages and plentiful supply of labor has retarded the application of mechanical and power devices to maintenance work.

The reports are all unanimous in recommending the use of mechanical appliances. How well this matter is summed up, in the other countries report, in the words, « mechanical devices should be tried for maintenance work, since in all fields of human activity the machine has eventually proved its superiority ».

Accounting.

Both the British and the American reports describe the manner in which the time worked by the men in the gangs is recorded and reported, how the payrolls are made out and how the returns made by the foremen or timekeeper are checked.

The reports covering materials received, used and on hand during the month are made by the foreman and sent in at the end of the month to the division office in much the same manner as the « time » reports.

As the present methods are reported adequate and no improvements suggested this subject need not be treated in further detail.

Material stores and distribution.

The system of handling maintenance materials and stores as reported for the various countries seems to be essentially the same. A central store or depot located at the division or district headquarters appears to be the general practice. These stores or depots are under the charge of a division storekeeper or stores superintendent, who is responsible for all stores on the division or district. On the American railways the division storekeeper usually reports to a general storekeeper who in turn reports to the purchasing agent. The intimate relation between « purchases » and « stores », leads to the opinion that the stores department should be controlled by the purchasing agent, through a general storekeeper. On some roads however, the stores department is attached to the operating department and the general storekeeper reports to the chief operating officer and as recommended in the 1914 American report follows the line of the divisional organization. The stores department has charge of materials for all departments on the railway and not for the maintenance department alone.

At the division storehouse all materials are stored until requisitioned for use, with the exception of large shipments of heavy materials such as rails, ties, bridge timbers for specific work, which are sent direct to the point where they are to be used and there unloaded, thus saving the large expense of rehandling through the storehouse. Only suf-

ficient material is kept on line of road to meet emergency demands.

In general the practice on British railways conforms to the American practice, except that it appears the maintenance department has its own store or depot independent of other departments of the railway, and that the stores superintendent is under the jurisdiction of the district inspector or chief inspector.

The other countries report considers it advantageous to supply the permanent way material for the whole system, with the exception of ballast, through the headquarters of the maintenance department, distributing it to one or more stores, according to the extent of the railway system. However, since it is necessary that there always be on hand a certain amount of material, it is advisable to establish a store for special material on each division or section.

An effective and economical way of distributing materials and supplies from the division storehouse is described in the American reports, namely the « Supply Train » system. This is a train of cars especially fitted up and equipped for the purpose and making, usually, monthly trips over each division, distributing, on requisitions previously placed with the division storekeeper, materials, tools and supplies, not only to the track forces but to forces of all other branches of the service.

If run under proper supervision much saving is effected by keeping the issues of supplies and materials down to actual requirements. It is possible to do this by the actual determination of the requirements on the ground by the officials in charge of the train. Also the gathering up of surplus material and placing it in line for use elsewhere effects a considerable saving.

The « reclamation » of usaleable old material and material that with repairs can be restored to usable condition or worked over into some other usable form, is mentioned in both the American and other countries reports. Reclamation plants have been established at central points to which all used and scrap material is sent to be carefully sorted and material fit for re-use, and that can be repaired is reclaimed and issued on requisition in place of new material. Great savings have been effected in this way.

This matter is considered in some detail in the other countries report, and in conclusion the opinion is expressed that it would be advantageous to allot to the divisions and sections an inspector whose special duty would be the control of the use of material, the care of tools and the careful sorting and classification of material taken up from track.

The economics of track labor.

Under the heading of « Methods adopted to effect reduction in cost », in the British report, there is found the statement that one British company claims to have effected economies of working through adopting statistical methods of observation, thereby making the better use of the men's time and reducing costs.

In the other countries report it is stated that on the Italian State Railway, a species of piece work had been introduced, whereby the minimum daily task per man was fixed for each length, and a bonus paid for each metre of track relaid over and above this amount. The results of this system were satisfactory.

In the « conclusions » at the end of the other countries report is noted that the application is favored of a system of fixing a time for each job in ordinary maintenance work. In summing up his conclusions the writer of the 1914 American report comments on the neglect of the equally important elements « Efficiency and economics in methods of performance ».

It seems recognized that there is

something needed to give better control over the track work, to give some measure of what amount of work should be done and a means of knowing promptly what is done, so that comparisons may be had and thereby knowledge as to the rating of the performance. With this knowledge steps may intelligently be taken for the improvement of the performance.

In the 1920 American report there is given in some detail the description of a system for standardizing methods of performing maintenance of way work for the purpose of establishing units of measure of work performed.

The main features of this system are :

1° A method of equitably distributing the available force;

2° Standard methods and time for each item of maintenance work;

3° Instructions to foremen to enable them to submit accurate reports of performance;

4° Closer supervision by means of planning and dispatching the work in advance;

5° Simple forms for the notation of records of performances and for comparison of results;

6° A reward in the form of a bonus or premium as an incentive to the worker to increase his output.

It is felt that this system is based on the fundamental principles of good management. It is a well defined plan for maintaining contact with and directing the work of a class of labor which, by reason of the extended territory over which it is spread is usually isolated and remote from that close supervision and direction so necessary to economic results.

It places available each day an accurate record of the performance of each gang, with its rating according to the established units of measure, for the use of the supervising officer in directing effort to increase effectiveness of the gangs.

The actual use of this system over a period of years has shown its applicability and its effectiveness in improving the efficiency of labor and in reducing the cost of the work performed.

From the preceding considerations the reporters deduce some conclusions that we think will be generally applicable.

QUESTION III

(Special steels).

The report will be found hereafter.

[624 .63 & 721 9]

QUESTION IV

(Reinforced concrete),

By W. W. GRIERSON, special reporter.

Seven reports have been drawn up on this question, *viz.* :

Report No. 1 (written in 1914) for all countries except Denmark, Sweden, Norway, Holland, Great Britain and America, by Marcel Castiau (1).

Report No. 2 (written in 1914) for Holland, as well as supplements to this report (covering period 1914-21), by C. Leemans (2).

Report No. 3 (written in 1914) for America, by the late C. H. Cartlidge (3).

Report No. 4 (supplementary report to No. 3, covering period 1914-21), for America, by G. A. Haggander (4).

Report No. 5 for Great Britain, by W. W. Grierson (5).

Report No. 6 (supplementary report to No. 1 covering period 1914-21), for all countries, except Denmark, Sweden, Norway, Holland, Great Britain and America, by A. L. Golard (6).

Report No. 7, for Denmark, Norway and Sweden, by P. M. Bülow (7).

These reports constitute a full and very valuable record of the extent to which concrete, both ordinary and reinforced, is used on railways.

It will be evident that within the space permitted detailed description is impossible, and that only in a limited number of cases is it possible to more than touch on personal expressions of opinion; it is very probable, therefore, that no reference is made to points to which an individual reporter may attach special importance, but if this be the case the discussion to follow will afford an opportunity to rectify such omissions.

In preparing the summary the procedure adopted in the case of several of the reports has been followed, of subdividing under separate headings the various purposes for which reinforced concrete and ordinary concrete have been used, and for convenience of reference the number of the Report referred to is given.

(1) See *Bulletin of the International Railway Association*, February 1921, p. 99.

(2) See *Bulletin of the International Railway Association*, January 1921, p. 3, August 1921, p. 1108, and February 1922, p. 347.

(3) See *Bulletin of the International Railway Association*, December 1920, p. 815

(4) See *Bulletin of the International Railway Association*, July 1921, p. 743.

(5) See *Bulletin of the International Railway Association*, July 1921, p. 761.

(6) See *Bulletin of the International Railway Association*, November 1921, p. 1815.

(7) See *Bulletin of the International Railway Association*, January 1922, p. 25.

The first conclusion to be undoubtedly drawn is that concrete, both ordinary and reinforced, is a material of great value for railway purposes, and, further, that while a considerable measure of agreement exists as to the purposes for which it may be advantageously used, such agreement is, in a number of cases, qualified by conditions dependent on the country and local circumstances.

There is however one requirement on which agreement is definite and complete, and indeed, insisted upon, namely, the absolute necessity of the use of suitable material, the employment of good workmanship and exercise of the closest supervision.

Composition and working stresses.

In many instances the description of a structure is accompanied by a statement of the composition of the concrete and shows that the proportion by volume of aggregate to cement varies from 2 1/2 to 1 to 4 to 1, the richer composition of 2 1/2 to 1 being used for a few railway underbridges, several raft foundations, one railway floor, and some platform and shed roofs and many piles; the poorer composition of 4 to 1 appears to be very general in Sweden, but in other countries 3 1/2 to 1 is a more usual limit.

The normal working tensile stress of steel of the many examples quoted varies from 14 000 to 17 000 lb. per square inch, but for floor decking and reinforced concrete arches, etc., this has been reduced in some cases to 11 000 lb. per square inch.

While it appears to be generally accepted that the stresses to which individual members of a reinforced concrete structure are subjected can be calculated almost as accurately as in the case of steelwork, it is nevertheless recognised that it is not possible to rely confidently that the ultimate strength of a given mixture of concrete will be equal to that shown as the result of tests previously made, and, further, that the margin of strength of a structure may, on the principle of the strength of a chain being equal to that of its weakest link, be greatly affected by any error of workmanship.

While reliance can be placed on the uniform quality of steelwork, this is not so to anything like the same degree in the case of reinforced concrete, the strength of which varies to a very large extent acording to the quality, size, and purity of the aggregate and sand used; the condition and make of cement, the care taken in the mixing of the composition, and the quantity of water used.

At the same time it is generally agreed that if the calculated working stresses are such as will admit of a reasonable factor of safety, structures designed on the basis of the calculated stresses have in practice been found to satisfactorily fulfil the duties they are called upon to perform, although it may be that some of them have not the margin of safety originally intended,

Foundations.

Ordinary concrete. — The value of the use of ordinary concrete as a means of levelling up the bed of a foundation and distributing the weight of a superincumbent load under normal conditions is generally recognised, and the quotation from Report No. 3 may be taken as typical of the general view expressed.

Reinforced concrete. — Several examples are given in reports No. 2, No. 5 and No. 7 of the now common practice of securing a structural foundation in weak ground by means of a reinforced

concrete raft or invert; while their efficiency and comparative economy under such conditions is recognised.

Piles. — All reporters are agreed on the efficiency of reinforced concrete piles as a foundation for a superincumbent load, and also that, pile for pile of equal size, reinforced concrete will sustain a considerably greater load than timber; but on the other hand it is recognised that a concrete pile is the more expensive : thus, it is stated in report No. 2 that while reinforced concrete piles can carry three times as much load as wooden piles, their cost in Holland is five or six times greater. In Belgium the cost of the two materials is said to be approximately the same for equal loading.

One disadvantage is referred to in Report No. 1, namely, the difficulty of gauging in advance the depth to which a pile has to be driven, and the consequently laborious and expensive work often involved by the necessity to shorten its upper end.

While many piles of various shapes and make are described, including special types suitable for sinking in soft, silty, or sandy sub-soil, those of the ordinary reinforced oblong, square, or octagonal section appear to be most favoured for general purposes, and perhaps preferably square or oblong, owing to their greater resistance to bending or buckling stresses and the greater ease with which they can be guided under the operation of driving. Caissons of reinforced concrete have been successfully sunk as supports to bridges. Reports No. 2 and No. 3.

Culverts.

Concrete, both ordinary and reinforced, has been largely used and to an increasing extent in all countries as a substitute for cast iron and earthenware pipes and masonry and brickwork culverts.

The economy which often results from the adoption of Box culverts in place of arched culverts is called attention to by reporter No. 3.

Railway underbridges.

It is probable that no question will give rise to more discussion and possibly greater difference of opinion than that of the suitability of reinforced concrete for railway underbridges.

It is not possible to state accurately the number of railway underbridges actually in existence, but the tables below include all bridges to which reference is made in the reports, and, as regards the larger spans, it is probable that the list is approximately a comprehensive one.

Where, as in the case of bridges enumerated under table No. 1 concrete merely acts as a substitute for brick or masonry, the maximum practical span depends on the stability of the foundations and the compressive strength of the material, and this appears to also apply to bridges enumerated in table No. 2 which it is understood from the description are merely slightly reinforced for the purpose of taking up secondary stresses : where, however, reinforcement plays an essential part in resisting the stresses imposed, questions of vibration and dynamic shock at once assume considerations of great importance.

Table No. 3 shows that arch reinforced concrete bridges have been constructed up to a maximum span of 297 feet, and table No. 5, that although quite a considerable number of straight girder underbridges of spans of 13 feet or less have been built there are comparatively few of larger span and none exceeding 50 feet.

COUNTRY.	Number of bridges of spans of 30 feet and under.	Number of bridges of spans of over 30 feet.	Maximum span.	*Remarks.*
(Table No. 1.) — **Ordinary concrete : Arches.**				
America	...	1	160′ 0″	
Belgium	3	...	26′ 3″	
Denmark	60	...	26′ 0″	
France	...	2	557′ 9″	
Italy	...	4	164′ 0″	1 of these bridges has 2 spans.
Total.	63	7		
(Table No. 2.) — **Ordinary concrete slightly reinforced : Arches.**				
America	...	2	150′ 0″	1 bridge has 9 spans and the other 7.
France	...	1	541′ 4″	
Russia.	...	3	101′ 8″	1 bridge has 7 spans and the other 2.
Sweden	...	2	72′ 0″	
Switzerland	..	2	328′ 0″	
Total.	...	10		
(Table No. 3.) — **Reinforced concrete : Arched type.**				
Denmark	...	12	72′ 0″	
Great Britain and Overseas Dominions	1	4	50′ 0″	
Holland	142	22	105′ 3″	
Italy	...	3	98′ 5″	1 bridge has 7 spans. 1 — 3 — 1 — 2 —
Sweden	...	7	297′ 0″	
Total.	143	48		
(Table No 4.) — **Reinforced concrete : Bowstring type.**				
Denmark	...	1	73′ 0″	This bridge has 3 spans.

COUNTRY.	Number of bridges of spans not exceeding 20 feet.	Number of bridges of spans exceeding 20 feet but not exceeding 30 feet.	Number of bridges of spans exceeding 30 feet.	Maximum span.	*Remarks.*
(Table No. 5). — **Reinforced concrete : Straight girder type.**					
America	Many, number not stated.	Many, number not stated.	2	50′ 0″	1 bridge has 11 spans and the other 6.
Belgium	Ditto.	None.	None.	19′ 8″	
Denmark	300	None.	None.	13′ 0″	
Great Britain and Overseas Dominions . .	1	4	6	50′ 0″	3 bridges have each 2 spans.
Holland	None.	2	None.	22′ 5″	
Italy	None.	2	1	32′ 10″	
Russia	None.	3	None.	26′ 3″	Each bridge has 3 spans.
Sweden	None.	1	None.	20′ 0″	
Total . . .	...	...	9		

The advantages and disadvantages of the use of reinforced concrete for railway and road bridges are discussed in the reports, and the more important may be shortly stated as follows :

Advantages. — Economy in first cost in certain cases; possible longer life than ordinary steelwork, and lesser cost of maintenance : a monolithic form of construction often advantageous under conditions of weak ground.

Disadvantages. — Greater headway required for straight girders while under construction; reinforced concrete cannot be brought into use until the material is thoroughly set : want of adaptability to enlargement or alteration : difficulty of replacement without serious interruption to traffic.

These are considerations common to both underbridges and overbridges, but the question of the efficiency of the material under conditions of shock and vibration, assumes added importance in the case of underbridges.

While it would not be correct to state that the reports are to be read as discouraging the use of reinforced concrete for small bridges of the girder type, or perhaps larger bridges of the arch type, carrying heavy and fast railway traffic, it is clear that the majority of the reporters are doubtful as to the advisability of its use, except possibly for quite small spans; the following extracts may be quoted :

Report No. 1 : « The use of reinforced « concrete has extended considerably in « the last ten years, except in the case of « subways and railway bridges in which « small spans only have been tried and « that with hesitation. »

Report No. 2 : « We are even of

« opinion that it is at present not advis-
« able to use reinforced concrete for the
« superstructure of railway bridges
« which are intended to carry a heavy
« and fast traffic, except in certain
« special cases.

« From the economic point of view it
« seems to us that a reinforced concrete
« structure intended to carry a busy
« service of heavy trains running at
« high speeds, is not superior to a
« masonry structure, or to an iron
« superstructure supported on concrete
« or masonry foundations. »

Report No. 5 : « Few reinforced con-
« crete underbridges carrying railway
« traffic appear to have been construct-
« ed in any country, and this may be
« attributed to the uncertainty felt as
« to the behaviour of and the effect in
« the course of time upon the material
« due to the passage of heavy trains at
« high speeds, accentuated no doubt by
« a sense of the very serious possible
« consequences attendant upon failure,
« or the necessity for expensive re-
« pairs. »

Report No. 7 : « Reinforced concrete
« replaces wood and steel with advan-
« tage in all structures which are not
« exposed to great impact or to vibra-
« tion. »

On the other hand the following occurs in report No. 3, written prior to 1914 : « Reinforced concrete as a mate-
« rial of railroad construction is emi-
« nently suitable for constructions sub-
« jected either to static or vibratory
« loads. »

It is perhaps, however, not very clear that this is to be read as a recommendation in favour of the use of reinforced concrete for railway underbridges.

Overbridges.

The value of reinforced concrete for the construction of bridges carrying roads over railways is generally agreed, and indeed insisted on, qualified, however, by many considerations, such as, the type of design which individual circumstances may permit or necessitate, the character of the foundations, and the relative cost and ready availability or otherwise of cement, aggregate, sand and stone, brick and ordinary steelwork.

It is at the same time admitted that it cannot be asserted *a priori* that the first cost of reinforced concrete overbridges is necessarily less than that of ordinary steel, masonry, or brick structures; the suggestion is made in report No. 1 that for spans less than 49 feet carried on simple supports the cost of reinforced concrete straight girders is generally less than that of steelwork, and, further, that arches of reinforced concrete can only be advantageously constructed for spans less than 90 feet, where the cost of brickwork is relatively high.

Footbridges.

There might at first sight appear to be some variance of opinion whether reinforced concrete can be used with economy for footbridges over railways, but this may not be so, and indeed, it is possibly agreed that while little if any advantage from the point of view of expense is to be looked for in the case of footbridges spanning two lines only, economy on the other hand may result when several tracks are spanned.

Bridgefloors

Flooring consisting partly or wholly of concrete, either ordinary or reinforced, has been largely used in America and continental countries, and to a lesser extent in Great Britain. Many different types are described.

There is general agreement as to the efficiency of these floors, the character of the type described depending mainly

upon conditions, such as available headway, and width between main girders, which according to report No. 1 should not exceed about 4 feet, if the thickness of the slab floor itself is not to be excessive.

Retaining walls.

Ordinary concrete has been used in all countries for many years past for the construction of retaining walls and with satisfactory results. Reference is made in report No. 6 to a practice formerly in force on the Belgian State Railways of constructing retaining walls of ordinary concrete faced with brickwork, a combination which, in the opinion of the reporter, is undesirable owing to the different properties of the two materials in respect of settling, contraction, elasticity, and expansion due to heat. The advantageous use of retaining walls of reinforced concrete is recognised where the sub-soil is weak, and where economy of space is important. Attention is called in several of the Papers to the necessity of providing expansion joints in walls of long length.

Buildings.

Concrete, both ordinary and reinforced, has been used in America and on the continent for almost every class of railway building, but in Great Britain and Overseas Dominions to a lesser extent and confined mainly to large warehouses, grain sheds, and offices.

The necessity for providing expansion joints in the walls and roofs of buildings is called attention to in several of the papers.

The following list covers the various class of railway buildings referred to in the reports :

Goods sheds and warehouses;
Grain sheds;
Office buildings;
Workshops;
Train sheds;
Locomotive sheds;
Coaling stations;
Passenger station buildings;
Waiting sheds;
Platform roofs;
Water tanks and towers;
Signal cabins;
Watchmens' cabins;
Oil houses;
Shelters;
Ice houses;
Chimneys;
Snow sheds;
Avalanche sheds.

Special attention is directed to locomotive sheds for the construction of which reinforced concrete is emphatically advocated in report No. 1 and report No. 6.

Some doubt, however, exists as to the advisability of the use of reinforced concrete for chimneys, as the following extracts indicate in report No. 2 :

« Very bad results have been obtained « with a certain number of small chim- « neys, made of reinforced concrete, in locomotive sheds.

« It is, however, uncertain whether « this destruction is produced by the « locomotive smoke, or whether it is « caused by the action of rain and of « the current of cold air striking the « outside of the chimneys, which are « heated to a very high temperature « inside. »

Sleepers.

Many railway companies in almost every country have experimented in the running lines with reinforced concrete sleepers, but it cannot be said with success.

Their weight, cost, the difficulty involved in their handling, and their inability to withstand shock are freely

called attention to, and also the difficulty of devising a satisfactory method of attachment of the rails to the sleepers.

In report No. 1, the view is expressed that time alone will show whether sleepers of reinforced concrete can be designed of a life equal to that of a timber sleeper, and at a cost no greater, and whether the difficulties of attaching the rail to the sleeper can be overcome.

In report No. 5 it is stated that many experiments have been conducted by quite a large number of companies in Great Britain but so far without success, and that the adoption of reinforced concrete sleepers as a substitute for timber would appear to be a long way off.

In report No. 7, attention is called to the difficulty in obtaining sleepers of reinforced concrete at a reasonable price and of sufficient strength, and to the fact that concrete appears to be unsuited to stand shock and vibration, and that, further, no satisfactory method of attachment of rail to sleeper has so far been found.

Report No. 2 states that reinforced concrete does not possess the necessary qualities to withstand vibration and shock. On the other hand the late Mr. Cartlidge, report No. 3, while admitting that experiments have not been successful, either physically or commercially, formed the opinion that it is possible to design sleepers with sufficient strength and that they should ultimately form a better track than is to be provided by timber.

Fencing.

It appears that Fence Posts of reinforced concrete have not been used in Denmark, Holland, Norway and Sweden, but in all other countries their adoption is becoming very general, it being pointed out that the difference in their cost as compared with timber is now small, while the longer life which they may confidently be expected to enjoy must result in considerable economy.

Many kinds of fencing are referred to, such as :

Post and wire,
Space and pale,
Close-boarded,
Gates, and
Footpath stiles,

all of which appear to have given satisfaction.

Telegraph posts.

Telegraph posts have apparently only been used in America and Great Britain, and even so only to a small extent the reason in the case of America being attributed to the greater cost as compared with timber, while the same reason is put forward in the case of Great Britain, and also the difficulty in handling them.

Signal posts.

Great Britain is apparently the only country in which reinforced concrete signal posts have been tried and with considerable success. They are said to cost about the same as timber at the present time, and to enjoy a longer life and require no painting.

Sundry purposes for which reinforced concrete and ordinary concrete have been applied.

The many other purposes for which concrete is adapted, and for which it has actually been used with, in a large number of cases, resulting economy in first cost, reduction in maintenance and extended life, is shown by the following list :

Permanent way :

Signal posts;
Telegraph posts;

Telephone posts;
Load gauge posts;
Mile posts;
Gradient posts;
Sign posts;
Lamp posts;
Wheel beds;
Crank beds;
Point rollers blocks;
Station name boards;
Station name posts;
Block sleepers;
Signal wire casings.

Drainage :

Pipes, 12 to 42 inches in diameter;
Inspection chamber covers;
Inspection chamber bottoms;
Invert blocks for 15 and 18 inch culverts;
Cover blocks for 15 and 18 inch culverts;
Gulley cover dished for grating;
Drinking troughs.

Building materials :

Building blocks of various sizes;
Window sills;
Window heads;
Platform coping;
Platform paving;
Wall coping of various sizes;
Steps, 14 × 6 1/2 inches.

Fencing and gates :

Posts for wire fencing;
Straining posts for fencing;
Posts for unclimbable fencing;
Posts for rail fencing;
Posts for close-boarded fencing;
Lattice fencing;
Gate posts;
Cattle pen posts;
Wickets;
Boundary posts.

General.

Effect of sea-water. — The effect of sea-water on reinforced concrete is dealt with at some length in report No. 5, and the general conclusion reached that reinforced concrete in a constantly submerged condition does not suffer, but that under tidal conditions deterioration may take place between the levels of low and high water and some few feet above, unless the concrete is itself impermeable or rendered so by the application of a waterproof material, the latter, however, being regarded as effective only for a limited period.

No definite conclusions are reached as to the effect of fresh water.

Waterproofing. — Concrete may be made impervious by including in its composition fatty mixtures, but generally at the expense of some loss of strength. Many trade compositions are referred to for outside application, and are said to be useful for a limited period.

Influence of electric currents.— While no definite views are expressed with regard to the effect of electric currents on steel reinforcement, they are not thought to be material. On the other hand, it is stated in report No. 5 that the rusting of steelwork of reinforced concrete is aggravated in damp sea-air by electric currents.

Effect of fire. — The fire resisting properties of reinforced concrete are generally recognised.

Tunnels.— Several instances are given of the lining of tunnels with ordinary concrete, and in report No. 4 (fig. 10) a railway vehicle fitted with the necessary plant is illustrated, it being claimed that this arrangement minimises interference with traffic on the railway.

Effect of locomotive smoke. — The question of the liability of concrete to suffer from the effects of locomotive smoke is discussed in several of the papers.

In America, six railways report deterioration, but, on the other hand, the experience in Belgium, France, Den-

mark, Norway and Sweden, extending over a period of six or seven years, appears to be that concrete does not suffer under these conditions.

In report No. 7, it is suggested that the liability of concrete to suffer depends to a considerable extent on the chemical composition of the coal used, and that such liability can be minimised by the use of a rich mixture of concrete.

CONCLUSIONS.

The conclusions attached to the respective reports if considered as a whole may perhaps be summarised as follows :

1. — Drawings for reinforced concrete must be prepared with minute care as to detail; work upon the ground must be carried out under the closest supervision, and none but suitable material must be used;

2. — Considerable allowance should be made for possible slight errors of workmanship and the known want of uniformity of the strength of concrete material, in determining permissible working stresses;

3. — Concrete, both ordinary and reinforced, may frequently be used with resulting economy as a substitute for timber, steelwork, masonry, brickwork and earthenware, due either to saving in first cost or subsequent reduced maintenance charges or possibly longer life;

4. — Relative costs depend on the character of the structure and on conditions which vary in every country, and frequently in different districts in the same country;

5. — The cost of maintenance of a reinforced concrete structure may be said to be about the same as that of brickwork or masonry, and less than that of steelwork.

Reinforced concrete has a longer life than timber, shorter than brickwork or masonry, and possibly longer than steelwork;

6. — The suitability of reinforced concrete for railway underbridges has yet to be demonstrated, other possibly than for quite small spans; for larger spans its adoption must at present be approached with caution;

7. — With care, and at no great expense, reinforced concrete structures may be made to present a pleasing appearance.

SECTION II. — LOCOMOTIVES AND ROLLING STOCK.

[621 .133. (01, 621 .134.3 & 621 .134.4]

QUESTION V

(Economic production and use of steam on locomotives).

By Maurice LACOIN, special reporter.

The question of the production and efficient utilisation of steam in locomotives has been sub-divided by the Congress Committee into three parts :

1° Superheating and compounding;
2° Feed water heating;
3° Special devices.

The replies collected on these three subjects by the two reporters (one for English speaking and the other for Latin countries), Mr. Churchward (1) and myself (2) have furnished information which is entirely in agreement and which leads to similar conclusions. I have therefore no real divergencies of opinion to bring to your notice, and I shall confine myself to setting before you the more important facts that emerge from our investigations, and to drawing special attention to those points on which it appears to me that an exchange of opinions may be useful. I will supplement these remarks by the general conclusions which arise from a comparison of progress made in the various countries included in our enquiry, and also by some facts that I think may be of use in understanding how it is that the problem is not dealt with in exactly the same way by all the different administrations which are supporters of the Congress.

I take this occasion to thank the Administrations and the Engineers who have kindly assisted the reporters in their investigations.

As Mr. Churchward has not drawn up any separate conclusions at the end of his report, you will excuse me if I give you only those which are attached to my own report, and add to these any fresh developments which may have taken place since the publication of the reports.

A. — Superheating and Compounding.

Development of the superheater on new locomotives. — Since 1910, the use of the superheater has been so far developed, that in recent years it has been extremely rare that new locomotives have been built without superheaters, with the exception of tank engines primarily intended for shunting.

This development shows that at the present time the superheater apparatus and the special devices for superheater engines have been brought to such a degree of perfection, that these locomotives may be employed as easily and with practically the same amount of

(1) See *Bulletin of the International Railway Association*, October 1921, p. 1527.

(2) See *Bulletin of the International Railway Association*, September 1921, p. 1157.

maintenance, as saturated engines, and that the superheater allows a considerable improvement to be realised both as regards fuel consumption and loads handled.

The type of superheater which has given most satisfaction is that consisting of elements placed in the smoke tubes. The arrangements used are various, but are in reality very similar. The elements are attached to the header, either by being expanded in, or more frequently by an attachment which can easily be taken apart. No difficulty is reported in keeping these joints tight.

As regards the valves, pistons and stuffing box packings, simple types have now been evolved which give entire satisfaction. Any inconveniences caused by the special arrangements adopted for superheater engines and the maintenance of the superheaters themselves are considered by the Administrations as being practically negligible.

On the other hand, the advantages obtained by the application of superheating are universally recognised as being very important. The reduction in the consumption of water and fuel per unit of work developed is the principal advantage obtained. This reduction also allows an increase in the available power that may be obtained from a locomotive of a given weight.

The figures given on this point by the various administrations, or for the different types of engines belonging to the same administration, vary widely. The advantages obtained by the application of the superheater depend in fact upon the degree of superheat obtained, the dryness of the steam, on the absence of cylinder condensation, and the class of work on which the locomotives are employed. The increase in power obtained is moreover limited by the power (as regards cylinder capacity) of the engine to which the boiler supplies steam. One must not be surprised therefore at the very different results that have been obtained, some of the less satisfactory results arising, among other things, from the fact that the necessary precautions for the efficient use of superheated steam, especially as concerns the valves being free from leakage, have not always been taken. In actual service, both passenger and goods, the economy obtained in the coal consumption varies from 5 to 25 %. Laboratory tests are quoted as showing an economy of 30 to 35 %. As a rule it is between 10 and 15 % compared with the fuel consumption of saturated engines. From tests on express engines, Mr. Churchward has found an economy of 25 %.

The majority of Administrations consider that there is an appreciable economy, even for locomotives engaged on suburban service. On the other hand, opinions differ as regards shunting engines. Some railways consider that the quantity of steam used is not diminished by superheating, because the demand is too intermittent. On other railways it has proved to be economical. It appears also that the railways which state that they have found no economy are those which have retained smoke box dampers with the object of preventing the hot gases from passing over the elements when steam is shut off. Thus, the superheater is applicable even to shunting engines, provided that the dampers for retarding the hot gases, when steam is shut off, are not fitted.

The increase in power obtained by superheating is also very considerable. The superheater has thus enabled very great progress to be made in locomotive practice. In America, it has been a factor in the success of the Mallet articulated engines, as without it they would probably have made little progress.

The very rapid advance of superheating on locomotives has among other things led to a tendency to standardise the types of engines, by doing away with the more complicated arrangements which have been experimented with and

adopted by many railways, both for dividing the work equally between the cylinders and as regards the details of the valve gears. Especially has the practice of continental Europe and other countries been brought into line, in consequence of the tendency to abandon the four cylinder compound type, so widely used in Europe in 1910. The war has also contributed to this unification, by introducing into Europe a number of engines of American construction, and it has also led to the construction of engines combining American types with European improvements, such as those of the Orleans Company.

The position of the problem of superheating does not appear to be identical in Europe and America. In Europe the maximum axle load being as a rule not greater than 20 tons, it is not possible to increase the power of an engine by simply increasing the power of the boiler without increasing the number of coupled wheels. Thus it is that the European Pacific class engines are as much limited by the adhesion necessary when starting, as by their boiler capacity. On the other hand, in the United States the axle load approaches 30 tons, and under present day conditions of superheating, this is sufficient to utilise the output of the largest boiler that the loading gauge allows. Thus it is that in America the tendency is to carry the superheat to a higher temperature and to use higher pressures. This is notably the case on the Pennsylvania Railroad in its latest experimental locomotives constructed by the American Locomotive Company, which are fitted with the Locomotive Superheater Company's type E superheater. In Europe the necessity for such experiments does not exist. It should also be noted that the European railways have as a rule taken advantage of the application of superheating to reduce to 12 kgr. (170 lb. per square inch) the working pressure of boilers which have hitherto been pressed to 15 or 16 kgr. (213 to 227 lb. per square inch) on compound engines. This reduction in the working pressure has the effect of reducing the cost of maintenance, and is also indirectly beneficial to the amount of superheat. In spite of this general tendency, it may be noted that the French Eastern Company has put into service a M. D. type superheater, designed with a view to increasing the degree of superheat. It will be very instructive if the United States engineers and those of the French Eastern inform the Congress of the results which they have obtained in their most recent trials.

Application of superheating to old locomotives. — A large number of railways have found it worth while to superheat old saturated engines. These conversions are made in various ways. For engines already fitted with piston valves, the alteration can as a rule be easily made when the boiler requires heavy repairs. When it is necessary to change the cylinders and motion, it entails much more work, nevertheless, some railways have thus rebuilt those of their engines which are of types not likely to become obsolete in the immediate future. For engines of a very old type, the conversion is generally considered to be too difficult, or even impossible, because of the increase in weight which it places on axles that are already loaded up to their limit.

One of the principal difficulties met with in this conversion is the fact that many old engines have flat slide valves. The majority of railways have not been successful in applying the superheater with flat valves, or else have been obliged to reduce the amount of superheat to a very limited amount in this case. Attention should be called, in this connection, to the very interesting application of superheating carried out, since the reports presented to the Congress were sent in, by the Swiss Federal Rail-

ways. This Administration has been successful in applying the superheater to engines with flat slide valves by providing oil ducts across the surface of the valve face. It will be of interest if the delegates of the Swiss Federal Railways give the Congress a report on this arrangement and the results obtained.

Special fittings adopted for superheat locomotives. — The details of the piston valves, relief valves, stuffing box packing, dampers for regulating the superheat, etc., have been discussed in the reports. If the practice of the different railways varies, it appears however that the only real point on which opinions differ is as regards the dampers for regulating the degree of superheat. In Europe, the use of these dampers has been as a rule abandoned, while in the United States they are still used. An exchange of opinions on this subject would be useful.

Compounding. — The reports show a very notable diminution in the use of compound engines. On many of the European railways the four cylinder superheater compounds have been replaced by engines of the two cylinder simple expansion superheater type, even for the most powerful engines. The theoretical advantage which may be obtained by combining superheating and compounding is in practice entirely balanced in engines of medium power by the internal resistance resulting from having twice the number of moving parts. As regards the more powerful engines, certain railways which have engines of both types in service consider that the two cylinder engine burns no more coal and is much more simple and reliable, and is therefore to be preferred. Certain other railways, however, advocate the continuation of compounding. The reports from the French railways who have been able in 1921 and 1922 to make a comparison of Pacific locomotives of both types on the same service, will make particularly interesting reading.

B. — **Feed water heaters.**

The feed water heating apparatuses, which were already under trial in 1910 have been improved or modified, while some new forms have been tried. Although some railways have commenced to use them on a large scale, it cannot be said that feed water heating is very general. In general use there are the three principal types of apparatus :

The types of apparatus in which a pump and surface feed water heater is used is the most numerous. Well known examples are Weir's apparatus in England, Caille Potonie's in France and Knorr's in Germany. Knorr's system has been largely used, but appears to still be undergoing certain modifications. The upkeep of all these apparatuses is as a rule a matter requiring care and gives rise to complaints on the part of the shed staff. Another variety is the pump in connection with the type of heater in which steam mixes with the feed water, as in the Worthington heater, tried in America and in Europe. Finally, in addition to these apparatuses, we have the exhaust steam injectors, which appear to effect an economy which is slightly less, but more dependable, and which have the great advantage of only requiring very little maintenance expenses, no risk of failures and no repairs. Metcalf's injector has been adopted by some English companies on all their locomotives.

The economies claimed by the various railways range from about 10 to 20 %, but it is very difficult accurately to estimate the results obtained. The reduction of the amount of steam that has to escape from the blast pipe, may have a very important effect on the back pressure, and consequently on the work developed in the cylinders. I believe that many railways should be able to give interesting information on this subject.

C. — **Special devices.**

The special devices which have been dealt with in the reports are too numerous to be dis.ussed here in detail. I will only state that the question of blast pipe orifices continues to be the subject of much experimental work, such as that on the Paris-Lyons-Mediterranean Railway, who have adopted a blast pipe known as the « trefoil » pattern, which divides the steam jet, and as on the Pensylvannia Railroad, where a single blast pipe has been replaced by four orifices set at the corners of a square and equally dividing the steam jet.

The use of water tubes has not increased. On the other hand, the practice of washing out with hot water is becoming general and decreases the stresses set up in the boilers. Special plants for re-using the hot water and steam in the boilers are very general in the United States. In Europe they are only used to a moderate extent. The advantages offered by these plants are, in fact, small when the engines are allotted to regular sets of men, and when there is time to wash out the boiler during the time that the men are resting.

The use of brick arches has become almost universal. In America these arches are supported by water tubes. In Europe the fireboxes are not so large, and no reports have been received as to the use of these tubes.

In order to arrange the discussion on these various devices, it would be convenient if the delegates who desire to take part would send in their names beforehand.

Proposed order of the discussion.

The discussion of the reports and the conclusions thereon may therefore be arranged as follows :

A. — **Superheating and compounding.**

1° Importance of the progress made in superheating. — Further possibilities. — Experiments now being made in this respect in the United States;

2° Application of the superheater to existing saturated engines. — Experiments made on this subject by the Swiss Federal Railways;

3° Retention of compounding for the more powerful superheater engines. — Four cylinder compounds versus two cylinder simple expansion;

4° Constructional details of superheater engines. — Retention or abolition of dampers for regulating the degree of superheat. Piston rod packings. — Air valves, relief valves and by-pass valves — pyrometers — distribution of steam by means of poppet valves, etc...

B. — **Feed water heating. — Results obtained with the various systems.**

C. — **Various devices to improve the production and efficient utilisation of steam : blast pipe orifice; washing out with hot water; brick arches.**

I have no amendments to make in the conclusions to my report, except as regards feed water heating, for which I propose the following modification :

« Although some railways have already made an extended application of feed water heaters, and the time appears to have arrived for their use becoming general; the trials carried out on numerous railways have not yet afforded sufficient information to allow definite opinions to be formed as to the superiority of one or the other types of apparatus. It is desirable that this matter should be definitely settled without delay, in order that these devices may be brought into general use. »

[621 .135 .2, 621 .135 .3 & 621 .135 .4]

QUESTION VI

(Bogies [Trucks], Axles and Springs of Locomotives),

By GEORGE HUGHES, special reporter.

INTRODUCTORY REMARKS.

In attempting to present a summary of three distinct reports upon such a subject as « Bogies (trucks), axles and springs of locomotives », and to reduce that summary in order that it may be presented within half-an-hour, it has been found impossible to do more than outline main points of the subject, and treat them in a manner that may help towards a discussion.

Further discussion will have to take place before it may be definitely asserted that such and such a method is the right one, and all others wrong, as is evident from the fact that each of the three reporters has, individually, found it almost impossible to deduce definite conclusions on the various points considered, as practice varies to such an extent on different railways.

Where, however, anything may be definitely laid down, it will be indicated in the following pages.

Types of bogies.

There are various methods of supporting the main frames of the engine on the bogie, the most important of which are :

1° Bogies with central spherical bearing;

2° Bogies with lateral spherical bearings;

3° Bogies with central flat bearing;

4° Bogies with lateral flat bearings.

The bogies with lateral bearings, whether spherical or flat, give a very steady engine as regards rolling, but opinions are divided as to whether they are, on the whole, preferable to those with a centre bearing, or not. This method of lateral bearings is known as the Alsatian system.

The American system, which is the one making use of a single support placed at the centre of the bogie, gives an equal loading of all wheels, and greater flexibility when entering a curve. In this system, the pivot forms the support of the load, being in the form of a plane ring-shaped surface, of which the outside diameter is about 12 inches. With very few exceptions the bogie pivot is placed in the geometrical centre of the bogie.

Controlling arrangements.

There are two methods of controlling side displacement of bogies, *viz.*,

1° By springs;

2° By gravity.

Gravity control may be divided into two systems, *viz.*, swing links, and inclined planes. The centring effort in the Alsatian type of bogie is supplied by springs either coil or laminated, the

(1) See *Bulletin of the International Railway Association*, October 1921, p. 1589.

choice as to which kind is adopted being apparently determined only by considerations of space available. The initial centring effort may have some definite value or be nil, according to whether the spring has any initial compression or not, but it is probably preferable to have an initial effort, so as to help to keep the bogie in its central position against the influence of jerks or small disturbing forces.

In the swing link, or American type, every swinging movement away from the central position causes a lifting of the bogie centre casting, due to its suspension on links. As this lift is infinitely small at the beginning of a movement, when simple links are in use, the initial degree of controlling effort is nil. Accordingly, the single links have, on the majority of railways, been replaced by triangular links, which provide a small initial effort against transverse motion. It is found more satisfactory to have a small initial effort to overcome, as although a bogie with no initial effort enters curves very smoothly, it is liable to set up an excessive rolling motion when on the straight.

The inclined plane method of control is only rarely met with, but is in operation on the Paris-Lyons-Mediterranean (see fig. 3 of Mr. Bochet's report). This railway states that all of its bogies are so fitted, and are quite satisfactory, being reliable and only requiring an almost negligible amount of upkeep. The sliding parts are enclosed in an oil bath.

Whether spring or gravity control is the better is difficult to determine. Gravity centring systems, however, appear to be simpler in construction and stronger than those with springs. In the gravity system the centring effort is always acting, whereas in the case of two or more springs, a broken spring causes loss of effort on one side, which may prove dangerous.

The length of the bogie wheel base varies considerably. Taking a ratio of the bogie wheel base over the gauge of the track, this ratio works out to results so different as 1.05 to 1.76 (see table 10 of Mr. Hughes' report). From an engineering point of view a ratio of at least 1.5 is desirable, but there are many factors to consider when designing the bogie, such as length of existing turntables, etc.

Opinion also varies very much with regard to the desirability of fitting brakes to bogies, as Mr. Minsart reports that the majority of bogies are so fitted, whilst Mr. Hughes finds that bogie brakes are very exceptional.

Details of bogies, methods of control for transverse motion, bogie springs, etc., will be found in tables 1 and 2 of Mr. Minsart's report; tables 1, 2 and 3 of Mr. Bochet's report; and tables 1 and 2 of Mr. Hughes' report.

Suspension.

On the whole, laminated springs are the most general for bogies, but there are various systems of bogie suspension. Some railways adopt the arrangement of an independent spring for each axle; others join the two springs on the same side of the bogie by compensating levers; others again employ the American system of a laminated spring attached at its two ends to two points on a rigid beam of greater length than the spring, this beam resting on the axle-boxes. The average flexibility of bogie springs (considered in Mr. Hughes' report) is about 0.249 inch per ton.

Bissel bogie.

This does not appear to be used to any large extent. The Swiss Federal and the Paris-Lyons-Mediterranean are discontinuing its use, and the Orleans Railway is confining its use so far as new construction is concerned, to engines intended for mountain lines. The above

remarks apply to the « Zara » type of bissel bogie, but a different type is in use on the Italian State Railways, and is very much in favour there. A drawing of this latter type is given in figure 9 of Mr. Bochet's report.

Pony and bissel trucks.

These, like bogies, may be constructed with either spring or gravity centring control. Helical springs are more often employed for suspension than is the case on bogies.

The length of the tail should be such that the axle shall be normal to the axis of the track, which condition can be satisfied if the following formula is adhered to :

$$x = b \times \frac{a + b}{a + 2b},$$

where,

a = Rigid wheel base;
b = Distance between carrying and leading coupled axle;
x = Length of tail end.

Radial axle-boxes.

To find the correct curvature of the radial box, Baldry's rule is :

$$x = \frac{a - \frac{b^2}{a}}{2}$$

where,

a = Centre of coupled wheel base to centre of radial wheel;
b = Half distance between coupled axles;
x = Length of radius required.

This rule (see fig. B of Mr. Hughes' report) really gives the correct radius, so that the wheels set themselves tangentially to the rails on all curves usually met with in practice.

Special steels.

The use of special steels for the lightening of moving parts is very limited, very little information being received upon this question, but the usual reply, where special steel is employed, is nickel steel for the crank axle.

Compensating levers.

These are only little used in the British Isles, but other countries — America in particular — make considerable use of them. It is generally realized that the better the permanent way, the less need there is for compensating levers.

Main springs.

For driving and coupled wheels, springs are generally of the laminated type. Coil springs are very occasionally employed, owing to considerations of space, and on a few railways helical springs are used on the main drivers and laminated springs on the remaining coupled wheels, this arrangement probably maintaining a steadier load on the main drivers. Considerations of convenience more than of stability determine the choice as to whether the springs are placed above or below the axle-boxes, and the general practice is to place them below, the boxes then being more easily lubricated.

Main springs are not quite so flexible, as a rule, as bogie springs, their average flexibility being about 0.238 inch per ton.

Balance weights.

Different rules for balancing are adopted by various railways, but they are all based upon the distinction between the revolving masses, which are always completely balanced, and the reciprocating masses, of which varying percentages are balanced. Table 9 of Mr. Hughes' report gives a number of

rules for balancing for different railways.

Connection between engine and tender.

The usual connection is a central drawbar, frequently supplemented by a pair of safety chains. Spring buffers are often employed also, but converging buffers are very little used.

Play between rails.

This influences the running of a locomotive to a certain degree. The less the play, in moderation, the more stable the running of the engine, and the less the wear on tyres. For the standard gauge (4 ft. 8 1/2 in.), play generally varies between 5/16 and 7/16 inch on the straight, more being allowed on curves; the sharper the curve the more the play.

Instead of allowing excessive play on sharp curves, the middle tyre flanges may be made thinner on engines with three or more coupled axles.

Flange lubrication.

This is a method for reducing wear on flanges, which is produced by side-thrust against the rail. It is in use to a small extent in America.

Superelevation.

Various formulæ are in use by different railways, but the resulting superelevation works out to very similar amounts for similar curves and speed restrictions. A list of some of the formulæ used is given in table 12 of Mr. Hughes' report.

CONCLUSIONS.

To sum up the conclusions arrived at in the three separate reports is difficult, as each of the three reporters finds so much diversity of opinion as to render it almost impossible to lay down definite laws. The methods mainly adopted, however, to facilitate easy running on curves are :

For the front axles, to have bogies, pony trucks, or Bissel bogies.

For the middle axles, tyre flanges to be reduced in thickness.

For the back axles, to have bogies, pony trucks, or axles with side play.

Sliding axles, especially when fitted in front of a locomotive that generally travels in one direction, should be fitted with a sensitive centring arrangement, which may be either spring or gravity controlled, but the latter method appears simpler, and more certain in its action.

Whether there should be an initial effort to overcome or not is open to question, but probably the majority favour the opinion that there should be.

Bissel bogies are not used sufficiently universally to enable conclusions to be formed about them, but Bissel trucks would doubtlessly benefit by being simplified, and the length of the tail piece should be fixed so that the axle is normal to the track or curves.

For suspension, on the drivers and coupled wheels, laminated springs of moderate flexibility are perhaps the best, as the friction between the plates has a braking action which reduces the amplitude and duration of the vibrations and oscillations.

Side compensating levers are especially advantageous on poor track or sinous lines. They should have sufficient points of suspension to reduce rolling oscillation. On good track, they are probably not worth the extra expense and trouble entailed in their provision and upkeep.

Balance weights for balancing the reciprocating parts of the motion should be as light as possible, so as to diminish shock to the road.

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QUESTION VII

(Passenger carriages),

By E. BIARD, special reporter.

The question of the improvements to be made in the construction of carriages with a view to increase in the safety and comfort of the passengers has been examined at previous sessions from various special points of view At the London Congress in particular, in 1905, the question raised had some similarity to that with which we are to-day concerned, but comfort and safety were not specially taken into account, as is the case in question VII which is much more general and the terms of reference of which deal with the composition of passenger trains as well as the construction of the carriages.

Five reports have been sent in on question VII. Two deal with North America : the first (report No. 1) was made by Mr. B. F. Bush (1), president of the Missouri Pacific Railroad Company, and had been published already in 1914. Mr. B. F. Bush having been unable to resume his function of reporter after the war, the question was taken up again (report No. 3) for America by Mr. W. J. Tollerton (2), president of the Mechanical Section of the American Railway Association, and general mechanical service Inspector on the Chicago, Rock Island & Pacific Railway.

(1) See *Bulletin of the International Railway Congress*, September-October 1914, p. 839.

(2) See *Bulletin of the International Railway Association*, October 1921, p. 1399.

Report No. 2 (Spain, Portugal and countries of those languages) is presented by Mr. de Vargas (1), chief locomotive and carriage engineer of the Spanish Northern Railway Company.

For Great Britain, the Indian Empire, Australasia and South Africa, report No. 5, Mr. David Bain, formerly carriage and wagon superintendent of the Midland Railway Company had been appointed reporter; Mr. David Bain having relinquished this position did not wish to retain his office of reporter, his successor on the Midland Railway, Mr. Robert W. Reid (2), has prepared report No. 5, making use of the documents collected before the war by his predecessor.

Finally, report No. 4 (by Mr. E. Biard (3), honorary chief engineer of the French Eastern Railway Company) deals with all other countries.

When it was a question of obtaining the information necessary for the preparation of their work, the reporters, accepting the invitation of the Permanent Commission, got into touch with one another in order to arrange and

(1) See *Bulletin of the International Railway Association*, May 1921, p. 461.

(2) See *Bulletin of the International Railway Association*, November 1921, p. 1859.

(3) See *Bulletin of the International Railway Association*, September 1921, p. 1205.

adopt a uniform list of questions. The text of this list of questions is reproduced in the appendix to reports Nos. 4 and 5. The information received from the various administrations is thus uniform and the reports of which it is our lot to make a *résumé* have a homogeneity which the extent and complexity of the subject rendered particularly desirable.

The way in which the various reports were presented was not, however, uniform; some peculiarities appear worthy of notice.

The report of Mr. B. F. Bush, notwithstanding its extreme conciseness, gives very exact information on the passenger rolling stock of the United States. The list of questions sent out by him to the railway systems which he dealt with has been appreciably simplified; the particulars are given under the form of very concise summaries of the replies received.

In the report of Mr. W. J. Tollerton the information covers a wider ground and deals with the whole of North America (United States, Canada and Mexico); it is also of more recent date; the statistics given of the composition of the total railway rolling stock of the three countries dates to the commencement of 1921. Mr. W. J. Tollerton presented his report in the same manner as Mr. B. F. Bush, following the text of the individual questions set out in the list of questions and giving a *résumé* of the answers received.

The three other reporters, English, Spanish and French, while following the list of questions in its main outline, have not given their *résumé* in the form of questions and answers; a more compact method of editing has enabled them to collect together certain portions which the division of the list of questions might have separated and this has enabled them to deal with the changes taking place in certain important features having more general interest.

In reports Nos. 2, 3 and 5 the text is accompanied by photographs of the principal types of modern carriages with drawings of the whole arrangement or of details of construction presenting specially interesting features. Finally some statistical tables give information as to the composition of the total rolling stock of certain railway systems or groups of systems.

The reporters have scrupulously observed the recommendations made by the Permanent Commission with regard to the scope to be given to their work. This was a great difficulty; some portions could only be treated in a purely descriptive and quite concise manner. A great number of questions could only be briefly touched upon whilst some others furnished matter for special reports.

Notwithstanding the difficulties we shall try in this general *résumé* to give the principal particulars supplied in the reports, to put in evidence the opinions that have been expressed on some important points, and to bring out the actual tendency in the general practice adopted by the different railways.

Instead of making a special and separate résumé for each of the reports that have been sent in, which would involve a great deal of repetition, we think it better to follow the general common plan, taking care to introduce in course of this the peculiarities which are found in the descriptive portions of one or other of the various reports, and to note matters of more general character on which the authors have laid particular stress.

The author of report No. 4 (all countries other than those using the English and Spanish languages) had to consider a group of railway systems the rolling stock for which is of the most heterogeneous character. For this reason he has thought it well, at the commencement of

his report, to set out some general questions, on the one hand on the essential conditions to be met in order to ensure safety and to increase the facilities for comfort, and on the other hand the general methods to be kept in view in order to satisfy these conditions as closely as possible. We shall ask permission to sum up these very briefly on account of their general bearing and also because, taken together, we think they reflect fairly well those which have also been formulated by our colleagues, although perhaps in rather less ordered form, in the course of their respective reports.

I. — General conditions for safety and comfort.

A. — Safety.

The continuous development of traffic on the railway systems, the increase of the load, and of the speed of the trains, has rendered the general question of the safety of transport more and more difficult and complex. So far as the passenger carriage is particularly concerned, the conditions of safety which depend on its construction may be considered from three points of view :

1° The prevention of accidents to a train while running;

2° The diminution of the destructive effects of accidents (derailment, collision, fire, etc.);

3° The prevention of the individual accidents to which passengers may be exposed (carelessness, criminal attacks, etc.).

1° *Prevention of accidents to trains while running.* — In a train in order of running each carriage must, as much in its own construction as in the method of its coupling to the adjoining carriages, fulfil all the conditions necessary to assure its own stability on the line and that of those to which it is coupled.

Strength is, of course, the first condition to be fulfilled; it is necessary that the carriage should, in its complete form and in each of its different parts, be able to withstand the static and dynamic forces which are normally produced in ordinary service.

Now in order to be and to remain rigid, it is necessary that the carriage should have been well designed, that it should have been well constructed, and that it should be well maintained.

The technical value of the design of a carriage depends on the care with which the best conditions for ensuring the strength of the underframe, of the body, of the wheels and axles and of the couplings, have been considered — so as to ensure the free and regular working of these parts — the arrangement of safety appliances for the prevention of abnormal play, or of fracture, or of parts becoming detached, — and, finally, the general arrangement of the constituent details of the carriage in such manner that, even at the greatest speeds that may be attained, the running should be safe, smooth, and free from movements or shocks capable of producing derailment.

Strength, ease of running, and stability also depend essentially on perfect workmanship. The construction should be carried out in accordance with all the rules of the craft. The choice and quality of the materials, their adaptation to their purpose, and rigorous inspection and checking of technical specifications are of great importance.

Finally, in order that safe running should be ensured, it is also necessary that the carriage should be kept in a good state of repair. We shall not enter here into what principles should determine the best arrangement for maintenance of passenger carriages, because the question deals only with their construction, but we shall consider the leading part played by inspection and mainte-

nance of rolling stock with a view to safety while running. We must not, however, omit to take all proper precautions for ensuring rapidity of inspection and rendering easy the maintenance of all those parts of the structure of a carriage which have an influence on safety of running.

2° *Diminution of the effects of accidents.* (Derailments, collisions, fires, etc.) — In consequence of the continued increase in weight and speed of trains resulting from the progressive increase in power of the locomotives, the inertia to be instantaneously overcome in case of collision is greater and greater and the destructive effects of accidents are more and more serious. These effects cannot be reduced except by rapid and efficient action of the brakes, and from the point of view of the construction of the carriages by an increase in the strength of the main details composing the vehicle beyond the limits which would have sufficed under the ordinary conditions of normal service.

In this connexion it is generally recognised that longer and heavier vehicles, as is the case with bogie carriages when compared with those having independent axles, behave better in accidents than shorter and lighter rolling stock.

The method of carrying the body on the underframe, and the intimate connexion of the two in the case of the independent tubular system of construction, have great importance from the point of view of reducing the troubles caused by derailment and collision, particularly when telescoping occurs.

This may be rendered less serious thanks to the presence of unoccupied portions at the ends of the coaches, such as the vestibules, by a strengthened construction of these parts, or by special arrangement of the buffer-gear.

One of the most frequent causes of serious injury to the passengers in case of accident is the production of splinters of wood. The substitution, to as great an extent as possible, of metal for wood has reduced dangers of this class. Construction entirely or almost entirely of metal for carriages tends to diminish the risks of the production and spreading of fire while running, and particularly of reducing the much more serious effects of such fires as may break out after collision, fires which are almost always caused by the scattering of the burning fuel from the locomotive firebox on the debris of the rolling stock, or on to the clothing and luggage of the passengers.

Finally, arrangements, such as the installation of safety appliances on the carriage itself, are now provided for assisting the passengers to get clear of vehicles that may have been overturned or smashed and damaged in collision or derailment.

3° *Prevention of accident to the individual.* (Carelessness, criminal attacks.) — Passengers are sometimes, while travelling, the victims of accidents which may be attributed, sometimes to an accidental defect in the rolling stock and more frequently to a want of care or attention on their part; in this way accidents occur in getting on and off the train, doors are opened at the wrong time, fingers are crushed in the jamb of doors and windows; some improvements that have been made from day to day in the arrangement of carriages and in the many details of their construction have been made with the sole object of protecting passengers from their own carelessness.

With regard to criminal attacks, the various methods of internal arrangement of the coaches have their respective advantages and their disadvantages : the most effective measures consist in placing an alarm signal for the use of the passengers, an arrangement that is compulsory in the majority of countries, and some supplementary arrangement such

as inspection windows and the bolting of the doors of the carriages from inside the compartments.

B. — Comfort.

The chief points which have rendered it necessary to consider the question of comfort in the designing of modern rolling-stock are numerous; the frequency of travelling, the increase of touring, the length of journeys, the increase in speed, the increase in distances run without stops, etc.

In the search for comfort, two points have to be kept in view; in the first place comes the avoidance, or reduction, of the causes of fatigue such as shaking, vibration, noise and other objectionable circumstances inherent to travelling; and in the second place giving passengers certain facilities or advantages by means of special arrangement of accommodation.

By improving the running of the carriages at very high speeds the first point is attained. It is of interest to note, in this respect, that those solutions which enable this first result to be obtained, that is to say to improve the conditions of safety in relation to the running of the vehicles have at the same time been favourable to comfort; it is thus that the adoption of bogie coaches has, from the point of view of comfort, ensured progress which is perhaps still more marked than that relating to safety; the easier springing and the quieter running, in fact, count amongst the most essential conditions to be observed for rendering travel as much more comfortable as it is less fatiguing. Among those elements of comfort that belong to the second class, of which it appears that the passengers are particularly appreciative, must be classed in the front rank those arrangements which relate to health, — that is to say lighting, protection against cold and heat, washing and water-closet accommodation, and also all those details of construction which tend to enable the carriage to be kept clean and finally include arrangements for disinfection.

With regard to the facilities depending on the arrangement itself or on the details of the arangement of the carriage bodies, these are themselves of two classes : on the one hand, more or less ease in moving about on the train according to whether the carriages are fitted with a partial corridor, an arrangement which allows of access to the water-closet, or whether they have through corridor communication which gives facility of access to the restaurant car; on the other hand there are facilities in the arrangement of the compartment itself which depend on many details; area and cubic contents per seat provided, dimensions and upholstery of the seats, arrangement of the latter, method for separating the seats, arrangement of the bays, and finally numerous details and accessories, carpets, arm-rests, luggage nets, ash trays, movable tables, etc., not to mention the internal decorations which are also of importance.

The degree of comfort on the same railway system and for carriages intended for the same service, suburban or mainline, depends, of course, on the passenger-rates in force, from the lowest class up to that on which the rates are the highest not taking into account those compartments with draw-out-seats (*couchettes*) or with beds, in which seats or berths can only be taken by paying a special extra rate.

The degree of comfort varies also from one railway system to another or from one country to another according to climate, the time taken on the journey, the refinement of public taste and the degree of democracy of the inhabitants.

For these different reasons the limits between which comfort may vary comprise a great range in the scale of realization.

In regard to this subject, it is not out

of place to mention as has been done by several reporters, that too luxurious installations are costly, difficult to maintain, and that they involve an increase in the weight of the carriages and consequently increase in the cost of working; it is therefore advisable in this case to take care not to incur expense which may be out of proportion to the end in view. This is all the more necessary at the present time when the upheaval in general economic conditions, caused by the recent war throughout the world, compels many railway systems to exercise the most rigid economy.

II. — Types of construction and general arrangement of the carriages.

Passenger carriages show a comparatively large variation in construction and arrangement. The particulars given by the various reporters, however, enable the principal features of the rolling-stock to be given for each country, or group of countries, which they had respectively under consideration.

1° North America.

(Messrs. B. F. BUSH and W. J. TOLLERTON, reporters.)

The carriages on the large railway systems of the United States, of Canada and of Mexico, have uniformly general characteristics; all carriages are on bogies, with through corridor communication, and entrance platforms at the ends, open in the old carriages and closed in modern carriages *(vestibules)*.

For 1st class passenger carriages (first-class coaches) which form more than three-fifths of the total (about 31 500 out of nearly 50 000) as well as the less numerous (2nd class) so called colonists coaches, the body has a central corridor. The same applies to the sleeping-cars of the Pullman type, which company owns the greater number of the sleeping-cars running on the railway systems under consideration (5 800 out of about 6 800).

There are also a certain number of carriages of modern type with closed compartments giving access to a side corridor. Finally, the total number of carriages on these railway systems comprises baout 1 800 restaurant-cars and 1 700 club and saloon-cars.

From the point of view of type of construction the rolling stock in use on passenger trains on the 1 January 1921 consisted as follows :

Entirely steel	30 °/₀ about.
Of wood with steel underframes . .	10 °/₀ —
Of wood	60 °/₀ —

In the last eight years 19 900 passenger coaches have been constructed for service on the railway systems which replied to Mr. Tollerton; and of these :

90 % were entirely of steel;
10 % of mixed construction with steel underframes.

The carriages that are entirely of metal are reserved for service on express trains running long distances; they are being substituted to an increasing extent for carriages of wood or of mixed construction. The all-steel carriage is thoroughly popular with the public and Mr. Tollerton thinks that the day is not far distant when all carriages intended for through service will be entirely or almost entirely constructed of metal.

The length of carriages of recent construction is 70 feet (21.34 m.). The ordinary 1st class carriages, with central corridor, have 88 seats.

For local or suburban services the old wooden carriages, generally 60 feet in length (18 m. 30), with open platforms are used.

2° South America.

(Mr. DE VARGAS, reporter.

On the three railway systems of South America that have replied to the repor-

ter — Central Argentine, 5 ft. 5 3/4 in. (1 m. 67) gauge; Argentine State Railway 1 m. (3 ft. 3 3/8 in.) gauge; and the Central Uruguay, 4 ft. 8 1/2 in. (1 m. 44) gauge; — the modern rolling-stock closely resembles the types in use in North America. All the carriages are on bogies; the equipment comprises carriages of 1st class and 2nd class, restaurant-cars and a fairly large number of sleeping-cars owing to the length of the journeys.

All-metal carriages have not yet been introduced.

3° European Continent and other countries.

In the countries of other continents the rolling stock is much less homogeneous. More conservative tendencies have often caused the old types of coaches to be retained. Nevertheless, in most of the countries that have replied to the enquiry of the reporters, a general tendency is found to modernize the types, and the execution of this has been specially rapid since the commencement of this century.

A) *British Isles and British Colonies.*

(Mr. R. W. REID, reporter).

On the railways of Great Britain nearly all the trains running long distances, and the important fast trains, are now made up of bogie coaches, with through-communication and corridors arranged laterally on the coaches. The length varies from 54 to 70 feet (16 m. 45 to 21 m. 35).

Some railway systems use bogie coaches with partial corridors, and without through-communication between the coaches, for fast trains.

The carriages with separate compartments, some with water-closets are used for service of secondary importance; the oldest are carried on four or six wheels; modern carriages used for suburban services are carried on bogies.

Mr. Reid estimates that about half of the whole rolling-stock is of recent construction; many railway systems no longer use rigid wheel-base carriages.

Leaving the electrified lines out of account, there have been only very few applications, and these on trial only, of all-metal coaches. With regard to this, Mr. Reid states that this method of construction may possibly not find favour in his country because of the corrosive action of the gases contained in the atmosphere of the most industrial districts of Great Britain. Mr. Reid also states that metal construction does not lend itself readily to carriages with side doors; and he concludes that, if it is to come into further use, it will involve an increase in the number of centre corridor coaches.

Mr. Reid also sets forth some arguments based on the small loading-gauge of the English lines, on the limit of weight carried per axle permissible on old bridges and viaducts, thus limiting the size and power of the locomotives, and he concludes from these that it will be better that efforts should be directed towards methods for preventing accidents rather than towards the construction of vehicles which will be of great weight, though better able to withstand collisions.

In the British Colonies the modern carriages are of construction similar to the vehicles running in the country from which they are generally exported.

All the important trains in the colonies are now made up of bogie coaches.

With the exception of India, where some railway systems have commenced to adopt it, metal construction for carriage-bodies is not usual; the bodies are usually built of native woods selected for being the least easily inflammable.

In India corridor rolling-stock has been abandoned on some lines which prefer the types having independent compartments, particularly as it is easier to keep them cool during the hot season.

In Australasia (New South Wales Go-

vernment Railway) the bogie coaches have a side-corridor with or without through communication. The corridor is of Z arrangement with a door at the centre of the body on some of the 1st class sleeping-cars.

In South Africa, 3 ft. 6 in. (1 m. 067) gauge, the bogie carriages have through-communication and open platforms.

In New Zealand, 3 ft. 6 in. (1 m. 067) gauge, the coaches are of the same type with through-communication and closed vestibules.

B) *Europe*.

(Mr. DE VARGAS, reporter for *Spain* and *Portugal*, Mr. E. BIARD for *other countries*.)

In all European countries, on the great railway systems, the introduction of bogie carriages has been very great and rapid since the commencement of the century.

The great express trains and the fast trains running long distances are now made up of this type of coach.

On the Continent there are still a large number of rigid wheel-base coaches running in service; but the proportion of this type still being manufactured is diminishing. The last patterns of four-wheel coaches put into service have an overall length and wheel-base much greater than the earlier coaches. Six-wheel coaches are comparatively few; this pattern has been replaced by the bogie type.

Report No. 4 gives detailed statistical information regarding the evolution of the modern types for each of the groups of countries forming the subject of the report. The same applies to the different methods of arrangement of the body; the type with separate compartments has been abandoned for that with the corridor; the lateral corridor is more usual than the central corridor.

Carriages with-through-communication, with closed platforms and with through gangways, are adopted on the large express trains and are used exclusively on the international trains; this type is also adopted for the sleeping-cars of the « Compagnie Internationale des Wagons-Lits ».

For fast trains, running within the countries, the type of coach with partial corridor and side doors is in use on many railway systems.

Other railways, such as the Italian State Railways, use carriages of mixed type, with side doors and a corridor communicating with platforms giving through-communication, for fast train service within the country.

Finally, with regard to the method of construction of the carriage bodies, the electrification of some lines has led to the adoption of types analogous to those used on the electrified lines of the great European capitals. The metal construction of bodies, adopted to avoid risk of fire, is a special feature of this rolling-stock. It appears probable that this method of construction will be adopted on the main lines, not only for such of these lines as will be electrified, but also for the others.

* * *

From these very brief notes some features may be found that are referred to later in the statement of conclusions.

III. — Details of construction. Accessories. — Various details.

The time allotted for the oral report not being sufficient to allow of mentioning, even very briefly, the multiple details of construction of a coach which relate to safety and comfort, we will confine ourselves for the moment to some general features. Regarding the arrangements of the interiors of the compartments, the accessories fitted, the details arranged on the coaches such as those relating to the brakes, the lighting, the heating, etc., we are obliged to refer to the

concise notes already given in the reports, while adding a necessarily still more concise review of these in our conclusions.

Bogies. — Six-wheel bogies are used in America on the heaviest coaches, such as those 70 feet in length. Up to the present this type of bogie has not found the same favour in Europe, even in the case of coaches of the same length. The four-wheel bogie appears to be suitable for coaches having a total weight of about 50 tons on the rails, and for some that are even heavier.

Underframe and body. — The construction of underframes with a central member and buffer and the arrangement of vestibule of the American coaches, lends itself well to the strengthening of the ends in such manner as to diminish the risk of telescoping and to reduce its effects.

The problem is less simple for the double-buffer coaches of European rolling-stock.

The American rolling-stock is fitted with the automatic central coupling, recent vehicles being supplied with friction gear for deadening the shock. Coaches of the European type, of great length, use buffers and draw-gear with compensating levers.

The carriages of recent types have, in all countries, the roofs carried to a greater height than in the old types. The clerestory roof arrangement is widely adopted throughout America; the roof of semi-elliptic arch-form of considerable rise is of more simple construction, it allows the body to be lighter and it gives approximately the same cubic content to the vehicle.

IV. — Make-up of trains.

The information given on this subject by the reporters is meagre, but sufficiently consistent to enable the principles to be ascertained on which the rules followed are based; to avoid repetition these will be given only in the conclusions.

« RÉSUMÉ » OF THE CONCLUSIONS OF THE REPORTERS.

The reporters have given their conclusions in different forms :

Mr. B. F. Bush gives no text.

Mr. W. J. Tollerton deals only with the three following points :

Uniformity of types, of arangement and of construction of American coaches:

Advantages of metal construction, or almost all-metal construction, for the coaches of express trains;

Almost exclusive adoption of electric lighting.

Mr. R. W. Reid frames his conclusions separately for safety and comfort :

Safety. — The improvements should relate to methods for avoiding telescoping and fire in case of collision. It is consequently necessary to consider the discussion of twelve points which particularly refer to :

All-metal or mixed construction of bodies;

Special buffer gear with large buffer area;

Connexion between the bogies and the underframe;

Methods for getting the passengers out of the coaches;

Relative advantages of gas and electricity for lighting;

Rendering the woodwork incombustible;

Safety catches on the doors;

Increased number of quick-acting valves for the continuous brakes.

Comfort. — The following are the principal improvements that have been made :

Improvement in the smoothness of running due to bogies and the greater length of the carriages;

General adoption of steam heating;

Improved methods of upholstering the seats.

Finally Mr. Reid mentions as matters requiring attention :

Ventilation, prevention of noise from the brake-rodding or from the vestibule frames, and some other matters which relate rather to maintenance than to construction.

Mr. de Vargas draws conclusions, the greater number of which are applicable indiscriminately to the passenger carriages of South America and of Spain; the others relate more particularly to the rolling-stock of the one or the other country.

Mr. de Vargas has followed the same order as in his report, in other words, has followed the list of questions.

The conclusions in report No. 4, by Mr. Biard, are given in the same order, which we have also followed in the general *résumé* which has been given above.

For this reason we think that we may avoid dealing at greater length with the conclusions of the two last reports and conclude with the statement of the general conclusions below; in which we have endeavoured to take account of the chief points raised by our colleagues.

The text which we submit for the consideration of members of the Congress does not pretend to be more than a basis for discussion. We have drawn it up in the belief that the resolution of the Congress on question VII will have three main ends in view :

To record the improvements made since the last session;

To call attention to existing practice and the tendencies of the present time, and

Lastly, to mention among the most important of them some special points on which further improvements are still desirable.

GENERAL CONCLUSIONS.

1. — The comfort and safety of the passenger, as well as economy in first cost and maintenance have been the determining factors in the design and construction of the passenger carriages of the railway administrations of all countries.

2. — Very important progress has been effected, particularly during the last decades.

3. — Safety has been increased by improvements in :

The reduction to the minimum of risks inherent to the rolling-stock, to trains while running;

The diminution of the effects due to derailments or collisions;

The increase in the individual safety of the passengers by prtoecting them against their own carelessness or criminal attacks.

4. — Comfort and also safety have led to improvements :

In the general arrangement of the carriages;

In their various details and fittings;

In the accessories which, at the present time, complete the vehicles.

A. — General arrangement of carriages.

5. — The bogie type of carriage is used exclusively in America. Its use is increasing in other countries and tends to become general for express and long-distance train service.

6. — The railway systems that are still constructing rigid wheel-base carriages have adopted types which, by reason of their increased length, of greater wheel-base and of increased weight, are better adapted for high speeds.

7. — At very high speeds, or on badly worn tracks, the bogie carriages run with greater stability then the four or six-wheel coaches.

8. — Bogie carriages usually behave better when derailed or in collision.

9. — With regard to comfort, bogie carriages have the advantage of smoother and quieter running.

10. — The four-wheel bogie is usually considered adequate, so long as the weight carried is not so great that the six-wheel bogie becomes necessary.

11. — It is desirable that the trials, that have been undertaken on certain railway systems, with a view to improving further the smoothness of running of the bogies, should be continued and that more trials of this nature should be made.

12. — In the case of local trains running on branch lines and in suburbs, new types of carriages, specially designed with a view to these services, have been constructed on certain railway systems; in many cases main-line rolling-stock of earlier construction is used for this purpose.

B. — International arrangement of carriage-bodies.

13. — Arrangements providing access to a water-closet tend to become general, as well as access to a restaurant-car on long-distance trains.

14. — Through-communication carriages with vestibules, or platforms and gangways at the ends are exclusively used in the United States. The majority of the carriages have the central corridor to which the American public is accustomed.

15. — In Europe carriages of this type are generally constructed with a lateral corridor giving access to the compartments.

16. — A great number of the European railway systems also use coaches with side doors, generally without through-communication, but sometimes with through-communication (Italian State).

C. — Type of construction.

17. — The elimination as completely as possible of combustible material enables the risk of fire while running to be reduced and it diminishes this risk particularly in the case of serious accident.

18. — All-metal carriages, or carriages made almost entirely of metal, have been introduced rapidly and are continuing to be introduced in America, where they have found favour with the public.

19. — In Europe the steel carriage has not been used to any appreciable extent up to the present, except for the vehicles on electrified lines. The resumption of the construction of new rolling-stock, on the various European railway systems on which this question is being investigated, will doubtless give opportunities for extending this method of construction by adopting it to various existing types of vehicle.

20. — The destructive effects of telescoping may be diminished to a certain extent by strong construction of the carriage-ends or by a suitable arrangement of the buffers.

21. — The introduction of certain constructional arrangements as well as the fitting of safety appliances in the car-

riages themselves, is now provided for in order to facilitate the escape of the passengers from vehicles that have been overturned, or broken up, or have caught fire as a consequence of collision or derailment.

D. — **Details of carriage fittings.**

22. — The comfort provided in modern carriages is mainly due to the methods adopted for the distribution and division of the compartments, to the increase of air space and to the area allowed per seat, to the upholstery of the seats, to the ventilation, to the internal decoration, and to the numerous improvements that have been introduced in the smallest details.

23. — On night trains, compartments with draw-out seats (*couchettes*) are becoming more and more numerous.

24. — Sleeping-cars, whether they belong to the administration or to companies such as the Pullman Company in America or the « Compagnie Internationale des Wagons-Lits » on the continent of Europe are becoming more and more comfortable. The tendency is to give the occupants more complete privacy.

25. — To protect the passengers from their own carelessness, improvements have been made in certain details, the form, assembly and operation of which affect safety : amongst these are the carriage-door locks, protection-bars on the compartment doors, or in the corridors, etc.

26. — With regard to hygiene, the greatest attention is and should be given to details of construction in affording the greatest facility for cleaning and disinfection.

27. — With regard to criminal attacks, it has been found that these have occurred on vehicles of every type.

The most effective method is to arrange alarm gear within reach of the passengers, and easily accessible, for warning the train staff or operating the brakes. The general tendency is to allow the passengers to effect the stoppage of the train rather than merely slowing the speed.

Small windows in the partitions between carriages (*glaces dormantes*) are also required in various countries.

E. — **Various appliances.**

28. — *Lighting.* — Lighting by incandescent gas has enabled considerable progress to be made as compared with previous systems.

29. — Notwithstanding the safety devices introduced into its use, gas is now, in some countries, considered to be dangerous and to be liable, if not to cause, at least to increase fire following on collision.

30. — Electricity, particularly for this reason, tends to replace gas completely. Improved systems are being applied from day to day. Special precautions are advisable for preventing short circuits.

31. — *Heating.* — The method of heating by steam from the locomotive is becoming more and more widespread.

32. — Recent improvements have been made with the object of better ensuring the flow of the steam to the last carriages of the longest trains, and to allow of regulating the heat in the carriages or in the compartments.

33. — *Brakes.* — The use of continuous quick-acting brakes has been extended on nearly all the railway systems; trials have been carried out to increase the rapidity of action and effectiveness of the brakes on trains which run at very high speeds, and which have become of increased length and increased weight.

F. — Make-up of trains.

34. — Almost all the administrations have drawn up rules with a view to ensuring a maximum of homogeneity in the make-up of passenger trains.

35. — Safety in running is, from this point of view, considered as ensured if each of the vehicles, taken singly, is capable, by reason of its weight per axle and its wheel-base, of travelling at the maximum speed of the train.

Owing to this, nearly all railway systems insist on either a minimum wheel-base or a minimum weight for all vehicles that are to be made-up into fast trains. Some administrations, in addition, require the grouping in a certain order, or in a definite position in the train, of those carriages which do not conform to the conditions laid down for weight and wheel-base.

36. — Other rules have been laid down regarding the interposition of buffer carriages at the front and rear of trains, the maximum number of carriages or axles per train according to the speed, and the type power of the engines.

37. — The adoption of more and more perfect types of carriages, the relegation of old types to less important services, the disuse of very old types, and the application of rules relating to the composition of trains, have combined to produce both an increase of safety and a very marked raising of the general average level of comfort in carriages of all classes.

38. — It is desirable that improvements and the application of such measures may continue to be carried out as far as the increased financial burden due to these, remains proportionate to the end to be attained and compatible with the economic position of each administration or of each country.

SECTION III. — WORKING (OPERATION).

[656 .212 & 725 .32]

QUESTION X

(Goods [freight] stations),

By Mr. JULLIEN, special reporter.

The Italian (1) and French (2) reporters insist, in the first place, on the importance of rapidity and regularity of freight transport as a factor in the industrial and commercial prosperity of a country, this having been amply demonstrated by the difficulties which have followed the termination of the war.

They proceed to point out that, in order to ensure this rapidity and regularity, it is necessary to make the best possible use, not only of the rolling stock, but also of the station accommodtaion, and that this depends :

On one hand, on the careful organization of the lay out (sidings, goods sheds and yards, private sidings), from a technical point of view;

On the other hand, on commercial transport conditions.

Technical conditions. — At the principal stations, the accomodation used for goods traffic should be entirely separate from that used for passenger traffic, and in small or unimportant stations, where the two classes of traffic are dealt with side by side, it is preferable, when circumstances permit, to place the goods yard on the opposite side of the main lines to the passenger station. This allows the points at the two ends of the goods roads to be more easily arranged.

At very important towns, there may be a number of goods yards specially provided for various kinds of traffic : cattle docks, depots for wine, harbour lines, etc. This specialisation of accommodation also occurs in the lay out of large stations.

A goods station consists of two parts :

The warehouses and unloading platforms;

The unloading yard.

The warehouses and platforms are as a rule provided with longitudinal tracks. Some Italian stations (Milan-Porta Vittoria, Milan-Scalo Farieri, Rome-San Lorenzo) have, however tracks at right angles to the length of the warehouse. Some warehouses are provided with several stories, as at the harbour station at Genoa-Porto Vecchio and the Paris-Ivry station. These are as a rule provided with power operated lifts.

The unloading sidings are arranged either as radiating in a fan shape, or else in the form of a letter X, with parallel spurs.

These roads should be laid out in such a way as to allow wagons being quickly placed at the disposal of the consignees, and the necessary shunting to be done without disturbing any considerable number of wagons and without hindering the work of unloading. Some rail-

(1) See *Bulletin of the International Railway Association*, January 1922, p. 5.

(2) See *Bulletin of the International Railway Association*, January 1922, p. 151.

ways even prefer to place the wagons brought in by the various trains during the day, in lie-by sidings.

This accommodation, both warehouses and unloading platforms and also unloading tracks, is in nearly all cases divided into two groups, one for dispatching goods and the other for receiving. The warehouses also include in many cases accommodation specially used for transhipping goods from one wagon to another. These transhipping sheds have tracks along their two sides.

Private sidings, when they are located in the immediate neighbourhood of the goods yards, may be considered as being part of the same, and greatly facilitate matters, provided the shunting necessary for their use does not give rise to excessive complication. This inconvenience as regards shunting is often experienced in cases where the sidings connect directly with the main line. In industrial districts, as for example the Paris suburban lines of the Orleans Railway, use is made of additional tracks to which the private sidings are connected, these additional tracks connecting with the main line at the stations.

The warehouses connected with the new Central Station at Milan, which are located under the viaduct which carries the station itself, and which are connected up by longitudinal tracks provided with turntables and spur tracks, form a solution of the problem analogous to that described above.

It is important that the sidings for arriving and departing goods trains and also the sorting sidings for these trains should be close to the loading and unloading points, and it is advisable, whenever it can possibly be arranged, that these groups of sidings should be connected to the loading and unloading sidings by independent lines. This condition is especially important at large seaports, where it is necessary to have at ones disposal, in the immediate vicinity of the quays, a number of tracks for the transhipment from wagon to ship, and close to these tracks to have covered warehouses, uncovered dumps and « silos » or hoppers for materials such as coal and other minerals. These lines for handling and storing goods should also be provided with ample sorting sidings, and it will be advisable to place these as close as possible to the docks themselves.

The work in the goods stations can also be speeded up to a considerable degree by the use of mechanical appliances, such as traversers, capstans, belt conveyors, suction conveyors, elevators or wagon lifts and electric auto trucks. The coal stages at the locomotive running sheds may to a certain extent be looked upon as stations specially equipped for handling and storing coal.

Commercial and administrative conditions. — Although the study of these conditions is dealt with at length in question XI, the programme for which includes the organization of freight traffic with a view to increasing the efficient utilization of the rolling stock and lines, it has, however, been touched upon by the reporters on question X. The commercial and administrative conditions of transport have such an important bearing on the question, that it is difficult, when discussing the best arrangement of the stations from a technical point of view, not to take into account this side of the question, if only in brief outline.

In this respect, the Italian State Railways lay special stress on the importance of losing no time in loading and checking goods that are to be dispatched, and in placing and unloading the wagons on their arrival. The delivery of advice notes should certainly be effected by the quickest method.

In order to speed up the loading of wagons by the public, the Italian railways have adopted the system of de-

manding a deposit from the consignor at the time of applying for a wagon, this deposit being retained by the administration if the consignor cancels his application or does not load in the stipulated time. As regards unloading goods on arrival, they charge warehouse fees and demurrage in order to stimulate promptness on the part of the public.

Similar methods, such as allowing a certain time for loading and unloading, adoption of special rates, fines for delays and a premium for time saved, and even the unloading of the wagons and removal of the goods by the railway itself, are resorted to in the various countries. In this respect, the facilities which are as a rule afforded to the public who have goods to be transported, for allowing the goods to remain on the railway premises for a certain time, either before dispatch or after arrival, are regulated by charging storage fees which are intended to prevent the abuse of the facilities thus afforded.

Conclusions.

1. — It is important in arranging stations that the goods traffic should be completely separate from the passenger traffic;

2. — In goods stations, special tracks should be provided for loading and unloading. These tracks should be connected whenever possible by independent lines to the arrival, departure and sorting sidings;

3. — These stations should be organized in such a way that wagons can be placed or drawn out at regular intervals, in sets, during the hours that the station is closed to the public;

4. — The use of mechanical devices, especially capstans, increases the efficiency of the stations and reduces the time taken in shunting. They are especially useful at seaports and in all cases where heavy goods are dealt with, such as coal and other minerals;

5. — Specialisation is to be strongly recommended for large goods stations. Separate warehouses should be provided for goods arriving, being dispatched, or transhipped;

6. — Fuller use should be made of private sidings, which increase the available capacity of the stations, and are of great assistance to commercial enterprise;

7. — In order to expedite the liberating of wagons, they should be placed at the disposal of the consignee, and advice notes sent out as quickly as possible on their arrival;

8. — Specially arranged rates may be of great use in speeding up the loading, delivery, and unloading of goods.

[656 .222.6]

QUESTION XI

(Slow-freight traffic),

By U. LAMALLE, special reporter.

§ 1. — Mr. EHRENFREUND'S REPORT [1].

Goods wagons.

The proportion between covered wagons and open-sided wagons varies according to the climatic conditions in the various countries.

The percentage of covered wagons to the total stock reaches as high as 83 % on the railways in South Russia, and falls to about 30 % on the Swedish State Railways, and even to 27 % on the Norwegian railways.

The majority of the railways dealt with in the Report show a tendency towards increasing the number of open-sided wagons, but at the same time they provide them with supports for sheets. Sheeted wagons are used for the conveyance of merchandise which is affected by wet, such as flour, grain, cement, etc.

On some railways the rates quoted for sheeted wagons are similar to the rates for covered wagons.

Within the limits allowed by commercial usage, and the maximum authorised load per axle, a tendency is noticed towards increasing the tonnage and capacity of wagons, with a view to increasing the profitable load in comparison with the tare. By so doing the return from the stock and the railways is increased.

All the railways consulted are endeavouring to standardise the types of their wagons in order to simplify the use and construction of same.

The task of constructing special wagons for those classes of merchandise which cannot conveniently be loaded in ordinary wagons has been left to private initiative.

In Italy the rates for conveyance by these special wagons are the same as for those belonging to the State railways. Empty vehicles are conveyed free for the same distance annually only in proportion to the distance they have been hauled loaded; any excess of empty mileage is charged for. Owners of these special wagons receive the benefit of allowances varying with the conditions of use.

Trains.

The majority of the railways show a tendency towards specifying the goods which may be conveyed on through trains for long distances between important stations. On the other hand they confine to ordinary trains all merchandise which only requires conveying short distances, or that which is sent from a starting point to a large depot for the purpose of being conveyed by through trains. This rule also applies in the case of goods unloaded from through

(1) See *Bulletin of the Internatianal Railway Association*, April 1921, p. 377.

trains and which require forwarding to another destination.

In drawing up time-tables for goods trains-which, of course, are dependent upon the working of passenger trains — a start is made by regulating the speed of trains which work on main lines. The time-tables for secondary lines are then drawn up in such a manner that the necessary connections may be made with the main line trains, for which they serve in the capacities of collectors and distributors.

The booked speed of through goods trains is from 15.5 to 25 miles per hour, and for ordinary trains 12.5 to 18.5 miles. The average speed ranges from 10.6 to 18.5 miles for through trains, and 6.2 to 10 for ordinary ones. In order to get the best value out of the engines the speed of trains is regulated according to the nature of the road. In a general way it is recognised that there is an advantage in limiting speeds so that the tractive power may be utilised as fully as possible.

Rapidity in transportation does not consist solely in attaining high speeds, but rather in shortening the length of time of stops at stations. Neither does quickness always result from following the shortest route, because one may be able to get better results, either by sending goods in a round-about way and thus benefit by connections with through trains; or by utilising lines with easier gradients.

Small consignments.

The considerations applicable to fully loaded wagons are equally applicable in regard to small consignments each time the latter are loaded in one wagon for despatch to the same destination, or to a station in the area where the distribution of the consignments begin.

At small stations, where fully loaded wagons are not dealt with, the unloading and loading of small consignments is done, from vehicles specially set apart for this purpose, whilst in transit. These vehicles must leave the starting point every day, even though they may be empty.

According to the opinion of the railway companies, it is considered that a wagon is economically loaded when it contains from 1 1/2 to 3 tons of goods. Beyond this weight two vehicles may be used.

In Italy « pick-up » trains working on lines with heavy traffic carry gangs of men who assist the station staffs in performing the usual operations.

Formation of goods trains

The maximum number of axles conveyed on goods trains varies according to the railways. The highest number is in Italy, where it reaches 160 axles on ordinary trains.

It is considered advantageous to adopt gravitation shunting for sorting operations in marshalling sidings.

Lay-outs at goods depots.

It is generally conceded that marshalling sidings should comprise three groups of sidings; one for arrivals, the second for sorting operations, and the third for the formation of departing trains. At the most important depots other groups of sidings are added in order to allow of the geographical classification of wagons.

Appliances for loading, unloading and transhipment should be provided in order to cope with the requirements of the traffic at the busiest part of the day.

In large goods stations, where the movement of wagons in warehouses is extremely heavy, use is made of sheds laid out in the form of steps (*en redan*), which are served by sets of rails laid fanwise.

Influence of rates upon the earning power of rolling stock.

In order to encourage the public to utilise wagons to their best advantage, the principle has been adopted of fixing a minimum load in proportion to the tonnage of the wagon. In some cases two different minima have been fixed, and a lower rate is charged when the highest minimum attained. An analogous principle is found in most « rates ».

The question of the grouping of small consignments by consignors is a subject for controversy.

Loading and unloading of merchandises.

Advice notes of the arrival of goods, etc., are forwarded by the quickest means.

Variable times are allowed for loading and unloading.

Efforts are made to prevent the delays incurred in unloading wagons, and the collection of goods from stations, by the imposition of penalties for delay to stock, and the enforcement of warehouse charges. Some railways do not confine themselves to penalties for time alone, but they also take weight into consideration.

Only in exceptional cases do railways take advantage of their right of unloading wagons themselves.-

The collection and delivery of goods by private firms present certain advantages.

§ 2. — SIR HERBERT WALKER'S REPORT (1).

In Great Britain, where goods are collected in the evening and delivered at their destination 200 to 300 miles away the following afternoon, division into fast and slow traffic is unknown.

The British railways are only able to achieve such rapid transportation by sacrificing, to some extent, the economical working of trains and the advantageous loading of vehicles.

If it were desired to make a connection between rates and transportation delays, it would be necessary for the Statutory Regulations to be altered.

British railways have made substantial progress in regard to better loading of wagons; also in the average load hauled by locomotives, as well as a reduction in dead weight in relation to profitable load.

For some time past the British railways have had a « common-user » arrangement in force, both in regard to wagons and equipment. The wagons and fittings of the various railway companies may be used for any load and to any destination. It naturally follows that this has resulted in economy in stock, due to the reduction in empty journeys, as well as to economy in sorting and shunting operations at depots.

The division of traffic between given routes (in place of allowing the public to choose the same), has allowed of the grouping of consignments into full loads, and this has resulted in a better service at less expense.

A reduction in the number of wagons used, as well as a reduction in the cost of motive power, has resulted from the introduction of mixed loading (*i. e.*, wagons loaded for two destinations).

A system of forwarding wagons on

(1) See *Bulletin of the international Railway Association*, November 1920, p. 731.

certain days only has been instituted with the object of increasing the number of full loads.

Heavy and light trains.

The present most economical system of increasing loads with a view to reducing the number of trains, cannot be carried on indefinitely, seeing that the power of locomotives cannot be indefinitely increased. Further, as speed is closely allied to load, if it is desired in future to maintain the present speeds, there is very little margin left for augmenting the loading.

The advantage of large capacity wagons is unquestionable, but this advantage is lost every time they cannot be fully loaded.

On those railways where the passenger traffic is very important, the interposing of a goods train between two passenger trains, may necessitate the running of the goods train at an increased speed with a consequently reduced load.

« Pick-up » trains.

In the Report only « pick-up » trains set apart for the conveyance of small consignments are dealt with. The necessity for care in establishing connections with other trains is insisted upon.

The staff whose duty it is to make up these trains must be acquainted with the local arrangements of the receiving stations in regard to the consignments. Vehicles loaded with packages and consignments should always arrive at the point of transhipment with the necessary advice notes.

§ 3. — Mr. GUERBER'S REPORT (1).

(Mr. Guerber's report deals with the position in 1914.

Return from rolling stock.

A. — **Capacity of wagons.**

At the present time France is ordering covered, open and flat wagons of 20-tons capacity only, for the conveyance of heavy goods. The 20-ton wagon, however, should be considered as a wagon of average capacity, and not as one of large capacity. Such as it is, it presents many advantages over stock of small tonnage from the point of view of station working; length of trains; shunting operations; and, likewise, in regard to the dead weight, which is 15 % less than for 10-ton wagons. Above all it is advantageous from the point of first cost — in general a 20-ton wagon only costs 25 % more than a 10-ton wagon.

In 1914, one third of the stock of a number of French railways was composed of 20-ton wagons.

Long flat bogie wagons to carry 40 tons are being considered.

Since 1903 the French railways have ordered 40- to 50-ton coal wagons, but only a small number have been constructed, and these are principally used as service wagons for the conveyance of locomotive coal. The railway companies encourage private firms to build such vehicles, and with this object they grant concessions in the way of rates. Some firms have ordered them for the conveyance of their own coal, minerals, and sand.

There is a tendency on the part of certain railway companies towards reducing the wagons set apart for commercial use to five types only, and this tendency is becoming more general. This would

(1) See *Bulletin of the International Railway Association*, June 1921, p. 641.

result in a reduction in the rolling stock; a simplification in the distribution of same, and a reduction in the number of empty journeys. Mr. Guerber, however, doubts whether any reduction in the stock would result from this unification of types, stating that with « special » wagons the facilities for storage and handling reduce the operating time.

In order to obtain a better use of open wagons, sheets are generally made use of at the present time, as this allows of the wagons being used in place of covered trucks. A certain number of wagons are provided with moveable sheet supports — the use of fixed supports has been almost entirely abandoned.

B. — Fixing of rates with a view to increasing the revenue.

Special rates have been instituted by the French railways for the conveyance of a given number of tons of merchandise in wagon loads — principally in regard to heavy materials.

Rates for the conveyance of animals are fixed according to the superficial area occupied.

Mr. Guerber sees in the application of a descending scale of rates a powerful means of increasing the return from the use of rolling stock; due to the fact that there would be longer loaded journeys.

Those French railways who endeavoured to speed up the liberation of wagons by the allocation of a bonus in case of a reduction in the usual loading and unloading time have now discontinued the bonuses. The usual time allowed in France for these operations is twenty-four hours.

The Northern Railway grants bonuses to their men at starting points for such services as making out documents; labelling and classification of wagons, and also the marshalling of trains. A notable acceleration has resulted therefrom in the departure of trains, and, consequently, a better turn-over of stock.

C. — Transportation arrangements.

With regard to the conveyance of small consignments, the French railways do not consider that there is any reason to go below 25-cwts for the composition of a full wagon load for one or more destinations; and they realise that it is impracticable to impose a higher minimum than 2 tons.

It is important that all local service lines and private sidings should be accessible by means of points, and it is not advantageous to have long sets of rails serving at the same time warehouses, goods-yards, platforms, etc.

Independently of the despatch of advice notes by the quickest possible means, and of repeat notes at the end of the morning, the reporter mentions the beneficial results which have been obtained by sending to the receiving station, in advance, advice notes, etc., under separate cover.

In addition to the mechanical appliances commonly used for the handling of marchandise, the Northern Railway also makes use of receptacles in the form of hoppers for materials in bulk. This class of material is unloaded direct from the wagons as soon as the latter have been placed in position on the stages.

A means to be recommended for checking the turn-over of rolling stock in stations and depots, is the chalking of the date and time on the wagon sides immediately they arrive.

For sorting sidings the type introduced before the war by the Northern Railway at Aulnoye may be recommended. Its characteristic feature is that there are three successive groups of sidings — the end sets sloping towards the central set which is laid out boat shape.

For speed in shunting it is important to have locomotives sufficiently powerful to be able to make quick starts and stops — in addition to rapid acceleration.

Shunting engines which have to exert all their power are necessarily slow; slipping of wheels results; drawgear is broken; damage is caused, and there are all kinds of trouble. It is important, therefore, that the engine should be sufficiently powerful to cope with the work which it has to do, and have a considerable amount of power in reserve. One of the principal factors in getting the best service is the employment of men on the engine who are well-trained and specialists in their work.

The granting of bonuses to men engaged in shunting is calculated to improve considerably the out-put of the marshalling yards, which consequently leads to a more rapid turn-over of the rolling stock.

The provision of through trains and « pick-up » trains is controlled by the volume and the distribution of the traffic.

The concentration of wagons at sorting sidings allows of the make-up of through trains between the latter; the final object being to get the wagons to destination as early as possible in the morning, with a view to their liberation the same day.

A general tendency is noticed towards an increase in the number of vehicles (or, in practice, the number of axles) composing goods trains. The figure of 80 adopted by the Paris-Orleans railway being more closely approached.

D. — Distribution of rolling stock.

In regard to the distribution of rolling stock, it is expedient to mention the organisation of special trains at high speeds to deal with the flow of returning « empties ». The average speed being about 30 miles per hour.

II. — « *Out-put* » *of the lines.*

The out-put of the lines is improved by the use of powerful locomotives. When necessary two engines are used in front, or a banking engine in the rear. This necessitates the increasing to a suitable length of the sidings and passing places.

The value of single lines may be improved by the despatch of trains in series at regular intervals of time or distance, but this assumes that there are at each station a number of lines to allow trains to cross.

According to the experience of the French railways, it is difficult to maintain a succession of trains on double tracks at intervals of ten minutes upon a journey of any length. In order to get a shorter spacing the substitution of an interval of distance for that of time has been tried, but it is important that this substitution should not increase the spacing anywhere, and it is therefore advisable that the positions of the block signals on which this spacing depends should be determined. It appears to be necessary to fix this spacing in a more carefully thought out manner than that which results from simply having block signals at level crossings — where the staff attends to the working of the block apparatus.

In order to get the maximum advantage out of the track it is desirable that the speeds of trains should be very much the same. In particular, when slow passenger trains are frequent their speed should be the same as that of the goods trains.

From the « out-put » point of view, where sidings are frequent the entrances to the same should be direct from the main lines — by means of points.

§ 4. — Mr. LAMALLE'S REPORT (1).

I. — Goods vehicles.

In order to comply with the private requirements of its traffic, the stock of the Belgian State Railways should consist of :

30 % of covered vehicles;
55 % of open-sided wagons;
15 % of flat wagons.

Thirty per cent of covered wagons is sufficient, because any shortage of them may be made up by the use of sheeted wagons. (It should be noted, however, that the Belgian State Railways have discontinued the use of sheet supports.)

On the other hand, the use of covered wagons in place of open wagons is rather diffi ult.

In order to increase the return from its stock, the Belgian State Railways avoid all specialisation. For instance, it leaves to private enterprise the responsibility of constructing stock for special purposes (the return journeys of which are generally empty), and confines itself to the five following categories :

1° *Covered stock :*

a) « Closed » (or box) wagons : 17 1/2 tons;
b) « Cavalier » wagons, for the conveyance of horses and cattle : 17 1/2 tons;

2° *Open-sided wagons* : 20 tons;

3° *Flat wagons :*

a) With two axles : 20 tons (30 feet long);
b) With four axles : 20 tons (40 feet long); 40 tons (60 feet long).

It is to be noted that the vehicles correctly described as « closed », and the vehicles known as « cavalier » (*i. e.*, vehicles for the conveyance of horses, etc.) present the same characteristics and they both have eight louvred, or shuttered openings in the sides. They may be used indiscriminately for the conveyance of the same class of goods — which results in a further reduction in the number of emputy journeys. The « cavalier » vehicle is distinguished from the other in that it is provided with side and end doors with the object of facilitating loading operations.

With a view of still further improving the proportion between the useful load and the dead weight of vehicles, the Belgian State has succeeded in reducing the tare of its stock by careful use of the material used in the construction of same.

Although at the time of the armistice the Belgian State permitted the use of ordinary open wagons belonging to private traders, it does not encourage them to acquire vehicles of a standard type, owing to the fact that private wagons, when running empty, are subject to the same limitations as loaded ones — that is to say they are consigned to a definite destination.

The excess of empty mileage over loaded mileage of private wagons is charged for in accordance with a scale laid down for empty vehicles running on their own wheels.

An increase in the earning power of stock has been sought for by increasing the tonnage and capacity. (The figures produced show the results obtained.)

It is obvious that if this is done an increased traffic proportionate to the increased tonnage per wagon can be passed through the sorting sidings, and this naturally postpones the time when extension becomes imperative.

(1) See *Bulletin of the International Railway Association*, August 1921, p. 1087.

II. — Organization of the train service.

A. — Transportation of heavy merchandise.

In consequence of the smallness of Belgium, the conveyance of slow goods traffic for the longest distance does not exceed 202 miles, and for this extreme distance it can be delivered at destination by means of through goods trains in 14 hours.

Be this as it may, merchandise forwarded in full wagon loads is picked up according to circumstances either by through, semi-through, slow or local trains.

Through goods trains are arranged according to the flow of the traffic. There is no object in arranging a through train except where the volume of traffic is sufficient, and the flow regular. Neither is it necessary to push too far the sub-division of traffic according to its description, otherwise the organisation of the trains would be too rigid, and on some days it would be necessary to forward trains incompletely loaded, resulting in uneconomical use of personnel and motive power.

If the flow of traffic has not the importance and regularity required for the organisation of a through train, the disadvantage may be remedied when several streams of traffic pass over a common section of the line from one depot to another. The transportation is then ensured by through trains over the common section.

For rapidity in turn-over of stock, and celerity in forwarding of goods, the ideal state would be to put all wagons requiring loading or unloading into the yards and private sidings in the morning; draw them out at mid-day; replace them with others which, in their turn, would be fetched out at the end of the day, and thus at night the yards and sidings would be quite empty.

Trains : Heavy or light; fast or slow.

In consequence of the heavy traffic on the Belgian State Railways many lines have arrived at the limit of their capacity, and it is no longer a question of finding out whether to arrange for goods trains which are heavy and slow, or trains which are light and fast, because for a long time it has been necessary to cope with the traffic with the smallest possible number of trains.

The questions now is — what is the limit of load for goods trains? This load limit is determined by :

1° The length of storage sidings;

2° The tonnage of the stock;

3° The distance between distant and home signals;

4° Safety conditions — notably by the connection between drivers and other men on the train.

All these conditions combine to limit the load of trains working on level, or very slightly undulating, lines within the limits of 1 000 to 1 200 tons gross.

It is not advisable to increase the speed of trains, on heavy gradients on account of the cost. It is, however, necessary to attain a fairly high speed up hill so that the speed of goods trains does not differ materially from that of suburban passenger trains, as the output of the road is thereby improved.

Through train services are arranged for as far as possible on these hilly stretches, and by the systematic use of two and three engines an average speed of 13 1/2 miles per hour is attained. This, however, is not so much the result of a high booked speed as the elimination of stopping places.

B. — Conveyance of small consignments.

Like the majority of railways on the continent the Belgian railways convey merchandise in small lots, either by

wagons which make a trip between two points daily (and which are not interfered with on the road), or by wagons which puck up and set down packages, etc., at intermediate stations.

When, however, a station has sufficient small consignments for another depot to make up a load of at least two tons, it places them in a special wagon which is sent direct to the destination.

III. — Influence of rates upon the earning-power of rolling stock.

In order to encourage their customers to send minimum quantities of ten tons, the Belgian State railways have introduced a sub-division into classes, the first of which is applicable to lots of 10 tons, and the second to lots of 5 tons; the latter being subject to an increase of 20 %.

The ideal system would be to establish classes for 20 ton lots, and secondary rates for 10 ton lots; but as there are still in existence many wagons of 10 to 15 tons, one is compelled (except in the case of special rates) to apply the most favourable rates to loads of 10 tons.

From the point of view of return from rolling stock the special Belgian rates are founded upon an obligation to send minimum quantities of 20 tons. For minimum quantities of 60 tons there are exceptional rates in force — a bigger reduction being made in these cases.

In order to accelerate unloading operations the advice notes are forwarded by the quickest possible means. The usual time allowed for unloading is eight hours — counting from the time of the receipt of the advice note by the consignee. When this time is exceeded demurrage charges are imposed per wagon per hour, is accordance with a progressive scale.

§ 5. — Mr. WILLIAM'S REPORT (1).

Rolling stock.

Out of the total wagon stock the number of covered wagons is about equal to that of open wagons.

The tonnage of these wagons is much greater than in Europe :

Covered wagons	32.66	metric	tons.
Cattle wagons	22.2	—	—
Refrigerator vans.	29.3	—	—
Tank wagons	35.65	—	—
Coal and mineral wagons . .	42.64	—	—
Flat wagons.	33.1	—	—

For new stock the tonnage reaches as high as 50 tons for coal and mineral wagons; and there is a marked tendency towards a capacity of 100 tons. The tare of 100-ton coal wagons is as low as 39 %; for all other classes of stock it is about 50 %.

The number of private wagons is very small as compared with the total stock of wagons (174 798 out of 2 632 141 vehicles-or 6.6 %), and the greater portion of the private vehicles are tank wagons.

Of the open wagons, one quarter of the total stock is composed of flat wagons; the others are either hopper, bottom-door, or tip wagons.

The distance which merchandise is conveyed upon the American railways, taken as a whole, varies from 1 to 3 500 miles, with an average distance of 325 miles; but for a single railway the average length of transportation is about 175 miles.

(1) See *Bulletin of the International Railway Association*, August 1921, p. 1087.

The railways carry on an average one passenger for two tons of merchandise. The average journey of a passenger is only one quarter of the average distance which merchandise is conveyed, but the mileage of passenger trains represents 45 % of the total mileage.

For the hauling of goods trains the American railways utilise engines of a very powerful type, such as « Consolidation », « Mikado », « Santa-Fé », and « Mallet ».

The working of wagons on « foreign » lines gives rise to demurrage charges from the « foreign » company to the owner. As opposed to the European Convention of Stressa (R. I. V.), the demurrage charge is a fixed, and not a progressive one. A special regulation is in force for private owners' wagons — these are charged for distance instead of time.

Lay-outs at stations and depots.

For loading packages and small consignments there are generally stations for departures and for arrivals. On an average the « departure » platforms are 20 to 25 feet wide, whilst the arrival platforms are about twice as wide — that is to say an average 40 to 50 feet. These differences are justified by the fact that the railway companies are masters of the situation in regard to the forwarding of goods, seeing that at their own option they may supply the necessary stock required to convey it. It is not the same, however, in regard to arrivals, where the collection of the consignments depends upon the celerity shown by the consignees.

Traversers and jib cranes are installed at those places where the frequent loading of heavy merchandise justifies them.

Electric trollies are only used in exceptional cases.

Loading and unloading of merchandise.

The large capacity of American rolling stock is a disadvantage in regard to the transportation of small consignments, seeing that such loads only represent 5 % of the total tonnage, and that no less than 23 % of the wagons provided daily are needed for its conveyance.

Contrary to European practice, merchandise proceeding to or arriving from sea is handled by the railway companies themselves.

Advice notes are sent by the quickest possible means.

The time allowed to consignees for taking away their goods is relatively considerable; it is fixed at 48 hours — after which demurrage or warehouse charges are imposed.

Station and train services.

In the « turn-over » of rolling stock, one fifth of the time is spent in working operations on the line.

The work performed in sorting sidings is set out in the following figures :

Ordinary shunting on the level, 50 wagons per hour per engine;

« Fly » shunting, 100 wagons per hour per engine;

Gravitation shunting, 200 wagons per hour per engine.

Express freight trains are run for perishables. The speed varies from 30 to 40 miles per hour, and the average is about 18 miles. These are the only goods trains which are run to a schedule.

The average speed of ordinary trains is about 11 miles per hour.

The American railways are constantly endeavouring to increase the tonnage hauled per train, and with this object in view they have recourse to the following :

1° Flattening out of curves so that the minimum radius shall be not less than 1 900 feet; also the reduction of gradients to 3 to 5 in 1 000;

2° Employment of banking engines on short inclines;

3° The use of two or three engines on heavy gradients;

4° An increase in the average tractive power of engines;

5° The provision of superheaters on the locomotives; auxiliary motors; and other devices tending towards economy;

6° An increase in the average carrying capacity of wagons.

The average useful train load has risen from 162 metric tons in 1889, to 612 metric tons in 1919.

Working of rolling stock.

The journey of wagons averages fifteen days :

36 % of this time is devoted to loading and unloading;

9 % to repairs;

20 % to railway working; and the remainder 35 % to shunting.

In 1920, the average load per vehicle was 26.3 tons, representing about 73 % of the inscribed tonnage, and the average journey per wagon per day in December 1920 reached 25 1/2 miles.

Rates.

With a view to the most efficient use of rolling stock, the rates per ton are lower for full loads than for partial loads.

In densely populated districts, large quantities of goods traffic, formerly carried by rail, have been diverted to road motor lorries. It is somewhat premature to say whether it is a permanent diversion of traffic, but if it is so it will probably relieve the railways of a class of traffic which is not very remunerative, and without inflicting much harm.

§ 6. — GENERAL CONCLUSIONS.

From an examination and comparison of the five reports, and the conclusions thereon, the following general conclusions may be adduced :

I. — Organisation of the conveyance of slow traffic with a view to increasing the earning power of rolling stock and lines.

Stock.

Within the limits allowed by commercial usage, and the maximum load permitted per axle, a general tendency is noticeable towards increasing the tonnage and capacity of wagons, with the object of increasing the useful load in relation to the tare. On the continent the present capacity of open and closed wagons is 20-tons.

In America 20-tons is always exceeded. Almost all covered wagons are 45.4 tons. The majority of new wagons for the conveyance of coal and minerals are of 50-tons capacity, and there is a marked tendency to still further increase the tonnage of coal wagons — more than 1 000 wagons have been built to carry 100 tons.

The improvement in the return from vehicles which results from increasing the capacity naturally exercises a beneficial effect on the earning power of the line as well.

Without being absolutely uniform in this respect, a large number of railways are endeavouring to restrict the number of types of vehicles, and more often than not they have adopted the four following categories :

Box wagons;

Cattle wagons;
Open-sided wagons;
Flat wagons with four pairs of wheels.

With the same object in view, the railways on the continent have left to private enterprise the construction of vehicles for special purposes.

The reduction in the number of types, and the leaving of the construction of special vehicles to private persons, results in simplifying the building of stock; it also results in a kind of « common » vehicle, which, by reducing the number of empty journeys, quickens the turn-over of the stock.

The proportion between covered and open wagons necessarily varies with the climate in the different countries, and the nature of the traffic to be catered for.

Be this as it may, the higher tare of covered wagons, the increased cost of same, and the difficulty in using mechanical appliances for loading and unloading them, have all caused the railways to, as far as possible, construct more opensided wagons (subject, however, to the provision of sheets for loads requiring same), and only build covered wagons for the conveyance of merchandise which absolutely necessitates it.

As difficulties in sheeting increase with the capacity of the stock, many railways provide movable sheet supports for sheeting the wagons.

When railways are divided between a number of owners in the same country, the « common-user » arrangement of stock has a beneficial effect in the way of reducing the number of empty journeys.

Trains.

The provision of through and « pick-up » trains is regulated by the volume and the distribution of the traffic.

It is advantageous to run a through train whenever there is a regular flow of traffic between two important stations which are at a reasonable distance from one another.

The provision of through trains, however, is dependent upon the importance of the traffic and its regularity. It may be carried too far, and thus bring about an uneconomical use of motive power and rolling stock.

There is a tendency towards increasing the number of vehicles both on through and ordinary trains, and the figure of 80 is being approached.

The possible out-put of the railway is increased by the employment of powerful locomotives.

The use of pilot or banking engines on short inclines, and the employment of two or three engines on steep inclines, is general.

The speed of heavy trains is fairly slow. Fast light trains are exceptional, and they are generally only employed for the conveyance of perishables.

An effort should be made to obtain higher average speeds — not so much by fast running en route, as by shortening the length of time at stopping stations.

High speed in transportation does not always result from following the shortest route, because better results can frequently be attained by diversion which allows of advantage being taken of connections with more direct trains; or by making use of easier stretches of the line.

With a view to getting the best possible value out of the track it is desirable that there should be very little difference in the speed of trains, and that, in particular, the average speed of slow passenger train should be the same as that of through goods trains.

Small consignments.

In the organisation of the transportation of small consignments, it is neces-

sary to take care that the attainment of speed is not detrimental to the best use of the stock. In this connection the minima imposed by certain railways in order to ensure full loading, have a tendency to increase, and they fluctuate between 1 1/2 and 3 tons.

It is interesting to note the practice of the Italian railways who send gangs of men on their pick-up trains to help the station staffs in the handling of the merchandise, etc.

The forwarding of wagons on given days only, as practised by the British railways, likewise ensures a more efficient use of rolling stock; but it also necessitates larger warehouses and greater care in regard to thefts.

Stations and depo s.

Rapidity in shunting is dependent upon the use of powerful locomotives which have a reserve of power, and which are worked by men with special knowledge and who are well-trained.

The allocation of bonuses to men employed in shunting is of advantage in getting the best out-put from marshalling yards, and, consequently, a better turnover of stock.

In order to facilitate shunting, more and more advantage is being taken of the laws of gravity, either by means of sidings on a slope, or by « humping ».

II. — **Influence of rates upon the earning-power of rolling stock.**

In order to encourage the public to use stock in a more advantageous manner, variable tonnage rates have been fixed according to whether the full tonnage capacity of the vehicle is used or not. In consequence, however, of the multiplicity of vehicles, and sizes of same, it has been necessary to fix several different minima, and in such cases the higher the minimum the lower the rate.

The granting of special rates gives the railway companies an opportunity of imposing higher minima according to the capacity of several wagons combined, or even to a full train load.

With a view to speeding up the unloading of merchandise, the advice notes are sent by the quickest possible means, and a large number of railways inform the consignees by telephone.

With the same object, demurrage charges are imposed for wagons which are not unloaded within the prescribed time, and these charges are calculated in different ways. Some railways do not confine themselves to penalties for time only, but they also take into consideration the weight of the goods to be unloaded.

When demurrage charges are based upon the length of time, they are either proportionate to the latter or based upon a progressive scale.

SECTION IV. — GENERAL.

[656 .224]

QUESTION XIV

(Customs examination),

By Mr. PRUDENT, reporter.

Basis of the present report. — The greater part of the information embodied in the present report was collected before the war of 1914-1918. It has been thought preferable to utilise this information rather than to take as a basis the present-day organization (obligatory passports for all nations — measures taken with a view to preventing the exportation of metals and money of gold and silver).

Different classes of frontier stations. — The two principal classes are :

1° Stations dealing exclusively with local traffic, and having no long distance through-train traffic : passengers, generally having to change carriages, pass with their luggage through the Customs Office; it does not appear possible to simplify the procedure in any way;

2° Frontier stations which, in addition to local traffic, receive and send forward complete trains (international trains) or through carriages and vans. We shall deal particularly with these stations, the number of which is considerable at the present day.

Different methods of inspection. — *a*) The oldest form of procedure is that which consists in passing through the Customs Office with or without luggage; the inconvenience of this system is well-known, and it is to be hoped that this procedure will be abandoned as early as possible.

b) The opening of parcels consigned to certain destinations. The Customs authorities permit the postponement of the inspection of certain registered parcels, carried without examination, to a given point beyond the frontier, under certain guarantees. Parcels which come under this head are of two kinds :

1° Parcels in transit which pass right through the country without intermediate delivery; in this case the procedure is practically uniform in almost all countries;

2° Parcels consigned to an inland station which possesses a Customs Office able to examine parcels; this class is less common, for certain countries have no inland Customs Offices, or have only a small number of them.

Great progress has been made in this connection in France, Belgium and Switzerland; and Denmark and Norway are excellently equipped from this point of view.

In the despatch of parcels thus accepted without special conditions, the Customs authorities must be given all necessary guarantees. For this purpose such parcels are either kept separate in special vans or compartments of vans which are sealed by the Customs; or, especially when few in number, each individual parcel is sealed. This sealing, however,

(1) See *Bulletin of the International Railway Association*, November 1921, p. 1801.

is generally inconvenient to the railway companies.

Certain countries, notably Switzerland and Denmark, rely in this case on the railway companies, parcels, duly registered and declared, merely receiving a Customs label, which calls the attention of the railway employees to their special character and prevents their being delivered except through the Customs Office at the station to which they are consigned. When thus labelled, a parcel may be handled as the railway company desires, as for example transfer it from one van to another, the only condition being that it shall be presented intact to the Customs Office at the station to which it is consigned.

This procedure appears to us the most satisfactory from the point of view of facilitating the work of the railway employees. It would be an advantage if it could be more widely adopted; and, if the individual sealing of parcels is definitely preferred as being the safer course, it is to be hoped that the sealing process, which is carried out free of charge in a number of countries, will become cheaper in those countries which make a charge for sealing.

In order that this procedure should be of the greatest possible utility, both as regards convenience and time-saving, the number of inland Customs Offices should, of course, be as large as possible. It would appear, at any rate as regards Europe and the particular countries with which we are concerned, that the number is not so large as could be desired. This point, to which the 1900 Congress drew public attention, again deserves consideration;

c) Inspection in the carriages : The Customs authorities only require those passengers to descend who have bulky luggage which has to be inspected at the Customs Office; small parcels carried by hand are inspected in the carriages.

This procedure is very general at the present day, especially with trains which pass the frontier complete; in this case, however, the Customs authorities generally require that the compartments and carriages should communicate with one another, so that the Customs officials have to get in and out of the train as little as possible. The inspection of such trains is correspondingly facilitated.

Inspection during the journey.— With a view to reducing the time spent in frontier stations, the Customs authorities have arranged, in certain cases, to carry out their operations during the journey, principally in the trains of the « Compagnie Internationale des Wagons-Lits ». This procedure, which is very common on the Italian frontier (Modane-Turin, Brigue-Domodossola), and in Denmark, Sweden and Norway, is still more generally used in the United States and Canada.

One great advantage of this method is the possibility of deferring the Customs inspection when the train crosses the frontier at an inconvenient hour of the night; in this case the Customs officials accompany the train sometimes for several hours after crossing the frontier, beginning their inspection at a prearranged spot.

Unfortunately, the Customs authorities generally require a rather high rate of remuneration for officials so employed, and this expense tends to restrict the extension of this very convenient form of procedure. It would be an advantage if, by means of mutual concessions, the above method could become more generally used.

Luggage detained by Customs authorities. — When registered luggage liable for inspection is not presented by anyone at the frontier station, it is, as a general rule, retained by the Customs authorities until the owner or his agent causes it to be inspected in the required manner. In several countries, particularly in France, Belgium, Sweden and

Norway, the railway companies are authorised to forward parcels, either as a matter of routine or on request, to the inland Customs Office which is nearest to the destination. This method may prove of great convenience to passengers, and in our opinion it would be advisable to introduce it wherever it does not at present exist.

Inspection of parcels on departure. — The Congress of 1900 considered the question of the possibility of carrying out the Customs inspection on departure. The maintenance of Customs officials in a foreign country appears to have been the principal obstacle to the development of this procedure, excellent as it is in itself. The question has already been settled between the United States and Canada. United States Customs officials are stationed at seven points on the Grand Trunk Railway (Canada), and Canadian officials in stations on the New Central Railroad and the Erie Railroad. According to the information received, this procedure works most efficiently and is greatly appreciated by the public.

It is to be hoped that this method will be adopted by other countries, especially in Europe.

Duration of halts. — The Customs authorities almost everywhere have realised the great desirability of shortening the time occupied at stations where there are Customs Offices; and as a consequence they have increased the number of their employees. At present it may be taken that from 30-40 minutes is sufficient for the inspection of a train of 250 passengers.

On the other hand, certain Customs authorities will not deal simultaneously with trains from different points. It is to be hoped that this rule will be abandoned, even though to do so may involve some modification of existing arrangements and an increase in staff.

International stations.— The Congress of 1900 recommended the provision of international Customs stations common to two countries. This recommendation, however, has been rarely adopted except between Switzerland and Italy, between Switzerland and the other surrounding countries, and between Italy and France.

This grouping in a single station of the Customs of two countries is undoubtedly an important improvement, because of the concentration of the services and of the shortening of the duration of the waits. It would appear that this is the most advantageous solution that can be recommended for the future.

Situation since 1914.

The war of 1914-1918 caused the abandonment of international trains in Europe. Some of these trains are already running again, but the measures adopted, both as regards passports and restrictions on the import or export of goods, still render international railway relations somewhat difficult.

For some time, however, there has been a marked tendency to simplify or even abolish Customs and Police formalities. An International Conference on the subject of Passports, Customs formalities and through railway tickets, held under the auspices of the League of Nations, formulated at its plenary session of 21 October 1920 the following recommendations :

The international passport, etc., conference proposes to the Society of Nations to induce the Governments to take immediately, and without delay, the following measures :

II. — Custom-house Formalities.

« 14. *Suppression of search of luggage « registered in transit.*

« Registered luggage only passing « through the territory of a State shall

« not be subject to any custom-house « examination. For this purpose they « shall have to be either lead-sealed sepa- « rately by the custom-officials, or phy- « sically separated from the remaining « luggage and goods not registered « through and carried in special trucks « or compartments equally lead-sealed « by the customs.

« 15. *Travellers and Securities in Transit.*

« Travellers in transit shall be entitled « at the entrance station to a country, « where there exists a prohibition of ex- « portation of funds, to have a certifi- « cate delivered to them acknowledging « the amount of the securities which « they possess and shall have the right, « at the exit station, to take out this sum « or these securities against remittance « of the said certificate. This faculty « shall be brought to the knowledge of « the travellers, with the same publicity « as the regulation concerning the pro- « hibition of exportation of funds.

The conference proposes also to the Society of Nations to communicate to the Governments the following recommendations, which, although their realization seems to be highly desirable, have not appeared capable of being set as an invitation...

2. — **Custom-House Formalities.**

« g) *International Stations.*

« That contiguous States should come « to an agreement between one another, « as far as possible, to make the sear- » ches effected by the customs coincide « at the exit and at the entrance of their « respective territories, by the recipro- « cal organization of common services.

« h) *Exit search of registered luggage.*

« That the exit search of registered « luggage should be made, as far as pos- « sible, at the departure from great « centres.

« i) *Entrance search of registered « luggage.*

« That the entrance search of regis- « tered luggage should be made, as far « as possible, on the arrival in the big « centres.

« j) *Searching the luggage.*

« Furthermore, that the search of « hand luggage, and registered luggage, « should be made, as far as possible, and « so far as the number of the checking « staff permits, in the course of the jour- « ney, in the intercommunicating trains, « and in the carriages, on stopping at « the frontier stations for the other « trains.

« That, with a view to simplify the « custom-house checking formalities, the « governments should see to a strict ap- « plication of the regulations concerning « the limitation and the nature of the « articles admitted for carriage, as lug- « gage. »

The preceding report has shown the utility of all these measures, especially as regards the establishment of international stations.

In conclusion, therefore, we would suggest that the members of the Congress should unanimously support the suggestions and recommendations made by the International Passports Conference on the subject of Customs formalities, as recorded in the official proceedings of 21 October 1920.

[656 .223 .2]

QUESTION XV

(Interchange of rolling stock),

By Mr. CHARRON, special reporter.

With a view of reducing as far possible the length of our discussions in the sessions, the Permanent Committee has decided that a single reporter be appointed to acquaint the section with the substance of the various papers which have been drawn up on the same question. Owing to the fact of Paris and Brussels being so close together as to permit of the exchange of correspondence much more rapidly than between Brussels and New York (the home of my colleague) I have been requested to undertake the task in regard to the question of the interchange of rolling stock, which has given rise to two reports — the first (No. 1) for America (1), and the second (No. 2) for other countries (2).

I am gratified at the opportunity thus offered me of paying respects to the paper of Mr. Crawford, the editing of which, full, substantial and concise, has greatly facilitated my work.

I am also pleased at the opportunity thus presented of setting forth additional facts which have come to my knowledge since Report No. 2 was drawn up.

The question before us has been discussed once previously by the Congress, at its fourth Session (Petrograd 1892).

It has again been included in the programme of the Congress for the present session in accordance with a request made at the last session (Berne 1910) by Mr. W. F. Allen on behalf of the American railways, who, in order that they might study the question, wished to benefit by the experience of railways in other countries where, they believed, regulations in regard to the interchange of wagons had made considerable progress.

The question, however, has been drawn up in much wider terms than in 1892. On the one hand it has been extended to include the interchange of all kinds of stock, and, therefore, comprises not only rolling stock but, in addition, all equipment (sheets, ropes, etc.) which may accompany it; and, on the other hand, it comprises not only uniformity between railways, but also uniformity between railways and consignors and consignees.

Report No. 1, in principle, was intended to relate to America, and report No. 2 to all other countries. As a matter of fact the only countries which have replied to the Questionnaire are North America (United States, Canada, and Mexico), Belgium, Denmark, Spain, France (and its colony Algiers), Great Britain, India, Australia, South Africa, Italy, the Netherlands, Portugal, Sweden and Switzerland.

It must be understood, therefore, that in this statement the remarks and general conclusions arrived at refer to these

(1) See *Bulletin of the International Railway Association*, number for September 1921, p. 1275.

(2) See *Bulletin of the International Railway Association*, number for March 1922, p. 479.

countries only, and — in exceptional cases — to those with whom (whilst not included in the above list) stock is interchangeable.

I shall deal successively with both aspects in the order in which the question has been put to the reporters, commencing with the agreements between the various railways themselves.

These agreements are settled either by mutual arrangement between two or more railways, and either in the same country or between different countries. The agreements, variously known as treaties, regulations, conventions, etc., will hereafter be uniformly designated as conventions. The conditions in the conventions are very numerous, and of varying importance; some of them relate to questions of order and convenient arrangements : these are, for example, those relating to the technical conditions attached to interchange, and to the way in which the documents which are to accompany the interchanged wagons are to be dealt with. I do not intend to dwell upon these details, which are of secondary importance from the point of view of the purpose of the conventions. Other conditions refer to the need of proportioning in the best possible manner the sums paid by the receiver of the wagon, calculated as to its importance, length of journey, and time occupied — periods of delay being calculated in days, half-days, or even hours; as to whether the charges should be the same for all wagons, or whether they should be calculated in accordance with the number of axles, or, further, according to the capacity of the vehicle. If these latter conditions are more important than those previously mentioned, the manner in which they are drawn up does not, however, sensibly influence, either for better or worse, the use of the interchanged stock.

The same remarks, however, do not apply to the last set of conditions, the object of which is to bring about the best possible use of the interchanged stock without injury to the interests of the owners and, at the same time, returning to the latter their wagons at fairly close intervals, in order that they may effect the necessary repairs as required.

Considered from this point of view the conventions may be divided into two classes. To the first class belong those in which each interchanged wagon becomes the object of a distinct account, and where it must be returned within a given time to the owning company, failing which that company has the right of enforcing demurrage. This class of convention is becoming less and less common. It is necessary, however, to add that this results from the fact that a large number of them have just been superseded by a single convention (belonging to the class in question) known as the R. I. V. (*i. e.*, Regulations for the reciprocal use of wagons in International traffic) agreed between the railways which use the standard gauge on the continent of Europe, and which was brought into operation on 1 January 1922.

The essential parts of this convention are the following :

The receiving railway must after unloading, return the wagons without delay, but, as far as possible, re-loaded.

The depôts authorised to re-load are, however, subject to restrictions, the object of which is to ensure the wagon being returned to the owning company as quickly as possible. Any failure to comply with these conditions involves a penalty of 40 fr. from the defaulting company to the owner.

Further, with the object of inducing the receiving company to keep the wagons which have been handled to them as short a time as possible, the demurrage charges are calculated in a variable manner, *i. e.*, from 2 fr. 50 per day per wagon, for each of the first three days,

up to 6 fr. per day beyond the fifteenth.

To this same class belongs another international convention, known briefly by the initials V. W. U., which governs the working arrangements between the railways of Germany, Austria, Hungary the Netherlands, and (subject to certain modifications in regard to demurrage charges) the arrangements between these countries and the Scandinavian countries who are not parties to the R. I. V. The edition now in operation of this Convention was put into force on the 1 January 1922, and it only differs from the R. I. V. in regard to the amont of the demurrage charges, and details which are of secondary importance.

According to recent information kindly supplied by the Danish State railways, it appears that they are in communication with the railways of two other Scandinavian States with the object of putting into operation fresh regulations based upon the lines of the R. I. V.

Consequently the interchange of stock between the continental railways using the European standard gauge will, very shortly, be subject to the R. I. V. system — except in regard to certain differences which have no bearing upon the essential clauses.

Considerable progress has therefore been made, and is being followed up, in the way of uniformity.

The second class of convention comprises those which do not necessitate the return of a given wagon in a given time. The most important, by reason of the number of wagons for which it is responsible as to interchange, is the one entitled « Regulations in regard to charges for the use of goods wagons » which has been in operation since 1 March 1920, between the steam railways of North America. Its characteristic feature is the fixing of a daily charge of 1 dollar per wagon, no matter what may be the length of delay. The charges from one railway to another, therefore, depend entirely upon the difference between the respective number of wagons of each company which are in the hands of another company on any day.

In order to prevent this system having the effect of prolonging the working of wagons off the owners' lines « Rules for the interchange of stock » (likewise put into operation on 1 March 1920) lay down conditions under which « foreign » wagons may be utilised by the receiving company. These conditions are drawn up in such a manner as to ensure the wagons working back in the direction of the owning company, even if they do not at once work back thereto. Further, the «Regulations as to charges» provide for a Commission to be set up known as the « Commission for the utilisation of stock », with instructions to control the application of both regulations, and with power to authorise alterations therein in order that wagons may be sent from one railway or territory to another, when this step, dictated by knowledge of the situation, is necessary in order to satisfy the requirements of traffic; also to improve the use of the stock; reduce the number of empty journeys; and, generally, to regulate the supply and use of wagons placed at common disposal for traffic between the several railways.

In Europe, one of the oldest types of convention belonging to the second class is that adopted by the Spanish railways for traffic working between two companies, and between one of them and a Portugese railway. These conventions are essentially based upon the consideration of balance between wagons of each railway circulating upon the lines of the other and, in case of a break-down in this arrangement, they provide for a daily charge per wagon to be credited to the railway which has the largest number of wagons running over the lines of the other. This charge of 2 pesetas for the first N wagons, N varying

from one convention to another, and, generally speaking, of 5 pesetas beyond N. Further, the company affected by the break-down of the arrangement may, when N is exceeded, and it wishes to reduce the balance to the latter figure, take steps such as the unloading at special depôts of wagons loaded to a destination on the lines of the latter at the expense of the debtor company, unless that company delivers a sufficient number of empty wagons to restore the balance to normal limits.

The railways in British India have adopted regulations based, similarly to the foregoing, on balance, but in a sensibly different form. In principle, it is incumbent upon the railway forwarding the traffic to provide the necessary wagons. If, however, the forwarding railway has upon the lines of the receiving company an excess of at least 5 % of its available wagon stock, or 600 wagons (taking as a basis the smaller of the two figures) it may ask the receiving company to supply as many wagons as it deems necessary to reduce the excess to 3 % of its total available stock, or 400 as a maximum (taking as a basis the smaller of the two figures), and to maintain the excess below the latter limit. If it does not comply with this request within the time and under the conditions stated in the convention, the receiving company pays a penalty, varying with the circumstances, of from two to four times the ordinary penalty for the wagons in excess of the balance exempt from penalties. The debtor company on its side has the right to diminish its liability beyond a certain limit by compelling the creditor company to take delivery of a certain number of wagons.

This formula is much more flexible than that of the Spanish conventions, seeing that the pecuniary penalty only applies at the request of the creditor company (not automatically), and that the debtor company has power to reduce its debit if the excess of wagons at its disposal is not required.

It is necessary to point out that some of the companies parties to the convention have decided to suspend its application from the 1 January last, and, by way of experiment (so far as concerns their broad gauge railways), to substitute for it a « common-user » arrangement in regard to their own stock. Amongst other conditions it is laid down that wagons must, as far as possible, be re-loaded to destinations on the owner's line, and the person in charge of the common pool has complete power as regards the issuing of orders to any participating company — within the limits defined by the agreement — to send stock on to the lines of another participating company.

I now come to the single Convention which, on 1 April 1920, the French railways substituted for the former conventions which united two companies between themselves and also between other neighbouring companies. By reason of the innovations which it contains, it requires a rather more detailed explanation than the preceding conventions. Like those of the same class which have been reviewed, it is based upon the consideration of balance. The framing of the convention has been complicated, however, by the fact that it is not only a question of balance between two adjoining railways, but of equilibrium on the whole of the railways who are parties thereto. The problem has been solved in the following manner :

The various types of vehicles owned by the companies have, for the purpose of the convention, been converted into fictitious units, called vehicle-units, and considered as equivalents in each of the categories flat wagons, hopper wagons, and covered wagons. It has been laid down as a principle that each railway must place daily at disposal in a common pool a number of vehicle-units fairly equal to the value of its total stock

in vehicle-units. An organization known as the « Central office for the movement of wagons » follows the exchanges from day to day, and draws up for each day and for each category of vehicle, the value in vehicle-units of the total stock of each railway in the common pool on the one hand, and on the other hand, the actual stock of which each of them enjoys the benefit. It establishes the difference between the totals of the stock and the available stock, and this constitutes the credit or the debit of each railway in vehicle-days.

Returning vehicles must as far as possible be sent back loaded, but this loading is subject to restrictions which ensure that wagons are to be returned within a reasonable time to the owning company.

In order to allow each railway to exercise its recognized right to the daily benefit of the equivalent of its own stock, it has been agreed that when, for a period of eight consecutive days, the number of the actual stock in vehicle-units upon the line of a participating company has been less than its total stock by more than a given fraction of the value of that stock, it is authorised to partially annul the restrictions imposed as to the utilisation of wagons of other companies, and it has the right to demand that steps be taken to replenish it with stock. The same thing happens when, for a period of thirty consecutive days, the stock in possession of the railways has been less each day than its total stock by more than 2 %.

In addition to replenishment in kind, the railway affected has the right to demand and receive a pecuniary indemnity which is made up from penalties from those railways whose accounts show an excess of vehicle-days of which they have had the benefit in proportion to the number of their local stock, and the charge is allocated between them proportionately to this excess.

Reciprocally, when for a given period the stock in vehicle-units as established upon the lines of one of the parties has exceeded its total stock by a certain proportion, this railway may be requested to pay an indemnity which is allocated between the railways whose account in vehicle-days shows a minus quantity.

In concluding with the principal Conventions of the second class I wish to say a few words on the systems in force in Switzerland and Great Britain. The first dates back to 1887; it is based on the practice of placing wagons in common use, and the allocation of same by a central office in accordance with the requirements of stations and depôts. Each railway company which uses another company's wagons pays to the latter the sum of one centime per axle per kilometre. It pays into a common fund at the end of the year a sum calculated upon the basis of 4 tenths of a centime per axle per kilometre for the total distance covered by the wagons which it has supplied to the common pool, and the receipts thus realised are divided between the constituent companies *pro-rata* to the number of wagons provided by each of them to the common pool.

With regard to the system on the railways in Great Britain — a system of « Common-user » pure and simple — this has been in use since 1917 in place of a system which was similar to those of the first class. This change was brought about by the fact that during the war the railways in Great Britain were almost all under the control of the Government. Although the control of the railways has since been handed back to the companies, the « common-user » arrangement for the use of wagon stock has been provisionally maintained. At the date when this report was being drawn up (end of January 1922) no definite decision had yet been arrived at, and the provisional arrangement had been extended to the end of March 1922 (1).

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(1) It has now been extended until 31 December 1922 at latest. (*English Editor*).

In addition to the systems properly described as « interchange », agreements are necessary in regard to the circulation of wagons on « foreign » lines in respect of the repairing of damaged wagons, and the allocation of the cost of same. The agreements entered into on this subject are of three kinds in regard to their essential clauses. The first is the American system; it sets out in detail the defects considered as debitable to the owning company, and those which are attributable to the company using the wagon. An examination takes place at all the exchange points and, when the responsibility for the defects is attributable to the railway using the wagon, a repairs label is attached authorising the cost of repairs to be debited to the railway responsible — in principle the repairs must be carried out at the nearest workshop, no matter who may be the owner.

The second type is the system adopted in the Regulations still in force between Scandinavian railways. The allocation of the cost of repairs is no longer based upon the nature of the damage which necessitates the repairs, but upon the amount of the cost of same. The expense incurred in attending to damage, except in those cases where it does not reach a given figure, is invoiced to the company using the wagon, and when the wagon has been working over several railways other than its own, this expense is debitable to the railway upon whose line the damage or defects have first reached the debitable amount, even though a part of the defects or damage may have happened upon the lines of another railway previously. The application of this rule involves an examination of the wagons by both interested parties at all exchange points. When a defect is noticed a remark is made in a special register, the entries in which enable one to discover the railway company which is responsible for the damage or missing parts. The damaged wagon is, however, sent back to the company for the repairs to be executed, unless the railway company which is using the wagon can readily attend to the same on the spot.

The third type is the system adopted in the R. I. V. Regulations and in the new V. W. U. Regulations, the originators of which, so far as this is concerned, have been prompted by the system still in force between the French railway companies themselves, and before the introduction of the R. I. V. in regard to the relationship between the French, Belgian and Italian railways.

The principle of this system is that the repairs to damaged wagons must only be carried out by the owning company — with the exception of slight repairs either to make a wagon safe to run, or to enable it to be used, or (in consequence of serious damage) to enable it to run home empty for repairs. These slight repairs are effected without charge by the company which executes them. As regards the repairs carried out by the owners, only when the wagon is loaded up is the cost of repairs invoiced by the latter to the railway upon whose lines the damage took place.

This system is a very simple one, and has done away with the need for a mutual acknowledgment of cases of damage, either at stations or in the workshops.

I have now finished with the systems in regard to the interchange of rolling stock, and shall only say a word in respect of the interchange of loose fittings (sheets, ropes, etc.). The question does not arise, either in America — where the equipment is provided by the Consignor at his own expense — or in Switzerland, where it is loaned to the Consignor. An effort, however, has been made to simplify the conditions in regard to the interchange of equipment when the cost of same is very small by foregoing the imposition of penalties for loss or delay.

I shall pass rapidly over the question of the establishment of interchange ac-

counts, and limit my remarks to pointing out the tendency towards centralisation of this work on the part of a number of the railways who interchange stock or materials. I note, further, the existence of a private enterprise which, at agreed price, has been commissioned to control the journeys of interchanged wagons on the private railways in Sweden.

In regard to the differences which may arise on the subject of the reciprocal use of stock, the understandings which have been arrived at allow of practically the whole of them being adjusted without the intervention of the Courts — and without appeal.

I now come to the second part of question XV which refers to the relations between railway companies and the consignors and consignees.

The first point to examine concerns the obligations and rights respectively of the railways and consignors in regard to the provision of stock. In most cases a request for stock on the part of the consignor does not create an obligation on the part of the railway company to comply with the demand within a given time — either by pecuniary penalties or otherwise. Certain regulations merely state that wagons must be provided to meet reasonable demands, it being understood that there must not be differential treatment between consignors. In some countries (but in very few cases) the railways must comply with the demand for stock in a given time — this is the case in regard to the Belgian State Railways and those of Switzerland — or, as in the case of the French railways, convey the goods within a given time, counting from the date when the demand for the stock was first made. In Spain, in default of wagons being placed at their disposal, consignors have the right of placing their goods on the railway company's premises, and of demanding an acknowledgment of the receipt of same — which materially increases transportation delays.

Once wagons are placed at the disposal of consignors for loading, or consignees for unloading, a certain free period is allowed for these operations to be performed. The time allowed varies very considerably as between one country and another; in some cases it is as low as 8 h., and in others as high as 48 — particularly in North America where, in certain cases, it may even be augmented by 24 h. Generally speaking, where the time allowed for loading is not the same as for unloading the latter is the longer.

Penalties for delay are provided for in the regulations when the operations of loading and unloading have not been performed within the period allowed.

In some countries — notably North America and France — it has been necessary to fix progressive penalties in order to encourage efficiency in this direction. Further, the French tariff is higher during that period of the year when the traffic is most intense.

As an additional inducement to consignees to improve their methods France introduced a system of bonuses (particularly during the busy traffic periods) to those who completed the loading or unloading before the expiration of the customary free period. As will readily be understood, however, this system has been almost entirely abandoned, because if the allocation of a bonus is likely to have a good result in regard to the better user of stock, it is an expensive way of attaining this result seeing that railways would be compelled to pay even for wagons which would have been unloaded before the expiration of the customary time of grace without this encouragement.

In North America, with the same object in view, a system has been put into operation called « averages », which consists of calculating penalties based upon the average detention of all wagons liber-

ated during the course of a month, and not based upon the delay in regard to each individual wagon. Although this system has its advantages the practice appears to have caused difficulties, as it is complained that it creates preferential treatment for large traders. In any case it appears to have been introduced in respect of wagons destined for works sidings and, according to the terms of report No. 1, it would appear that there is no plausible reason for extending the system of « averages » to wagons placed on public unloading lines.

So far as the railways are concerned, another way of hastening the liberation of stock, consists in their unloading themselves every wagon which has not been dealt with in the time allowed. The railways in most countries reserve to themselves this right by means of by-laws, etc.

What has been said up to now in regard to the relations with consignors or consignees applies more particularly to the operations carried out in stations or depôts. When wagons are loaded or unloaded on private sidings the system in operation differs from that at stations or depôts more or less according to the country. In North America there does not seem to be any difference worth mentioning. In the majority of other countries it is considered that the existence of a private siding leading directly into factories of works, and set apart for loading and unloading, allows of wagons being handled with less delay than is incurred in placing them in position in a station or depôt. As a result the delay in operating is frequently reduced by several hours. As regards penalties for detention in private sidings, in only a minority of countries are they calculated on a different basis from that employed in the case of stations or depôts. On the other hand, with the object of encouraging the users of sidings to attend to wagons outside the customary working hours of stations and depôts, certain French railways give bonuses in case the operations are completed before the expiration of the time allowed.

In almost all countries the railways have understandings with consignors and consignees not only in regard to their own (railway) wagons, but also in regard to those known as « private wagons » — purchased or hired by the consignors or consignees.

The use of these latter wagons relieves the railways of the necessity of providing rolling stock which is otherwise incumbent upon them. It is generally admitted that the owner of the wagon has a right to financial compensation for its use, and this is given either in the form of a rebate per kilometre (or mile), or by the application of lower rates. Some railways, however, — those of Belgium, the Netherlands, Switzerland, and « The South African Railways and Harbours » — do not make any allowance. The time allowed for loading and unloading varies considerably, but it is always at least equal to that allowed in the case of the railway companies' own wagons. Some railways make no charge, and others half charges, for the whole or some portion of the standing time when the wagons are at their home station or upon a private siding; others charge lower rates when the owner or hirer allows the railway company to place the wagon at any point to suit its convenience.

Another aspect of the relationship between railways and consignors is the provision to the latter of moveable equipment. The railway companies' obligation in this respect are very different in the various countries. In certain of them, such as North America, the railways never provide equipment. In others — France more particularly — this provision is closely regulated so far as sheets are concerned. In certain circumstances the provision is compulsory and free. In others it is either

compulsory or optional, but a charge is made in both cases.

Such, in its main outlines, is the state of affairs in regard to the interchange of material. In order to complete my Statement it is necessary to cite the opinions and conclusions of the two reporters. These are not exactly inconsistent but they reflect very different views. This is not surprising because one of them had little more than one system to analyse and comment on, whereas the other encountered very different systems — some being quite old, and others very modern. Be this as it may I will first sum up the opinions expressed in report No. 1, and reproduce textually the conclusions arrived at.

From the replies received by Mr. Crawford, it would appear that in North America no entirely satisfactory solution has been arrived at in regard to the difficulties presented by the problem. Although interesting experiments have been made — notably during the past few years — it does not appear that the fundamental principles and practical rules governing the better user of stock have materially changed.

So far as the agreements between the companies themselves are concerned the working of the interchange system is rendered very complex by the great number of different railways between whom is divided the ownership of the stock. It is obvious that public interest demands that regulations in regard to the use of goods wagons should be uniform for the whole of the North American continent. Further, it is unquestionable that a system of « common-user » of goods wagons (or at least those which can be used in common) by all railways would reduce to a minimum the difficulties which the allocation of such stock presents and, consequently, would doubtless have a tendency towards economy. But a system of this kind is neither favourable to the railways who have an abundance of stock, nor to those who have provided special types of vehicles in accordance with the special needs and requirements of their own customers. It is also necessary that the primary importantce of the maintenance of the wagons in a good state of repair should not be lost sight of and, whatever organization may be adopted, from the moment that traffic necessitates the circulation of the vehicles for long periods on « foreign » lines, arrangements are necessary between the companies concerned in order to ensure that this maintenance is kept up. The general opinion is that a system of absolute « common-user » would involve grave consequences, because the owners would not recover possession of their stock at sufficiently close intervals to enable them to effect the necessary repairs.

Further, rigid regulations relative to tho ownership of the stock, and the heavy fines inflicted in case of non-observation of these regulations cause serious inconvenience both to the railways and their customers. During times of scarcity the regulations as to the use of wagons have very little or no effect. When the traffic is very heavy the owners are liable to losses in goods receipts if they are deprived of stock equivalent to that which belongs to them, and when traffic is light the owners are often pleased to send their wagons on to other lines in order that they may benefit by the daily hire charges.

(Mr. Crawford sets out his conclusions at the end of the first part of his report on question XV.)

With regard to the understandings between railway companies, consignors and consignees — according to Mr. Crawford it is obvious that the companies cannot fulfil the whole of their obligations towards the public if their stock is diverted from its true role (which is to carry marchandise) as for instance, if a private individual uses a wagon as a

« warehouse » to the detriment of others who have a right to use it for the transportation of their goods.

Further, when wagons stand for an unreasonable time on unloading lines delay is incurred in placing other vehicles thereon. In view of the fact that public interest demands that regulations and penalties be applied in a uniform manner « The American Railway Association » has adopted a uniform code of conditions in respect of penalties for detention of wagons.

(Mr. Crawford's conclusions in regard to the second part of question XV are reproduced at the end of his report.)

I now pass to the opinions and conclusions in regard to report No. 2.

The opening statement refers to the tendency towards uniformity so far as the European international relationships are concerned, by the conclusion of two new agreements, almost identical, called « Regulations for the reciprocal use of wagons in international traffic » (known as the R. I. V.), and « Regulations for the reciprocal use of wagons within the areas of the railways belonging to the German Union » (known as the V. W. U.), to one or the other of which — subject to certain reservations on the part of the Scandinavian railways in regard to the V. W. U. — a large number of European railways have already become parties in respect of their relationship with the majority of other lines, and the first of which has, in particular, replaced the German-Italian Regulations (known as the I. W. R.), and all the conventions of the Frensch railways with those of neighbouring countries. With respect to the Scandinavian conventions of the same type as the old V. W. U. between Scandinavian countries, the railways concerned are considering their replacement by new conventions of the R. I. V. type.

Conventions of the R. I. V. type do away with charges for journeys, and introduce interesting alterations in regard to the imposition of time charges.

The tendency towards unification in international agreements had already been noticed in Europe, from the point of view of the technical conditions which wagons, admitted to the exchange, must fulfil, by the conclusion of an agreement entitled « Regulations as to the Standardisation of Technical work on Railways », which almost all countries, on the continent of Europe, who use the standard gauge have become parties to.

With respect to conventions between railway companies in the same country, most important changes have taken place since the question of the interchange of stock was brought before the Congress in 1892. The method of dealing with each wagon individually has been abandoned on many systems and not adopted on any fresh one. The new systems brought into force in France and British India during the early years of the present century have themselves quite recently been replaced — entirely in France, and, partially, by way of experiment, in India — by systems based on the « common-user » of stock. In France this modification has resulted in the substitution of a single convention in place of those between pairs of railways.

In regard to the relationship between railways and consignors or consignees; report No. 2 points out that they are regulated on very different lines in different countries. The influence which this diversity of practice has upon the use which the various railways may get out of their stock, according to whether they are required to furnish the stock or not; also as to the time — long or short — which the consignors or consignees have a right to the use of it without payment will be realised.

The obligations of the railway companies in regard to the provision of equip-

ment — more particularly in regard to sheets — are not less varied.

Having said this I might confine myself to reproducing the conclusions of report No. 2. However, it seems to me that it would be preferable both for the purpose of introducing information collected since they were drawn up, and in order to simplify the discussion which will follow the reading of this report, to substitute in place therof fresh conclusions inspired by those of both reports.

These conclusions are as follow :

A. — In regard to the relationship between railways themselves :

Since the previous discussion fo the question in 1892 fresh agreements have been arrived at with a view to bringing about a better use of « foreign » stock and, in certain cases, at the same time to simplify the keeping of interchange accounts, notably by foregoing charges for distance and the imposition of penalties for the detention of individual wagons. In certain of these agreements the principle of penalties being applied only at the request of the delivering company has been adopted. Many have drawn nearer, more or less, to the system of « Common-user »; others have endeavoured to correct the difficulties of the latter system by placing the working of rolling stock under the sole charge of a central office invested with the necessary powers to enforce the execution of its orders.

The principles upon which these innovations are based are rational. Some of them however, and amongst those the most important, are of too recent date to allow of one to speak as to their practical value, and until they have been subjected to a test of several years' duration this cannot be done. It is therefore desirable that the question of the interchange of material should again be placed on the programme of the International Congress for its next Session, in so far as concerns the regulations to be adopted in respect of the relationship between railways in regard to rolling stock.

B. — In regard to the relationship between railways and consignors or consignees :

a) The considerable deviations noticeable between countries in regard to the free time allowed for loading and unloading wagons, appear to indicate that the differing practices in certain countries are capable of being modified in such a way as to bring about a better use of rolling stock; also to improvements in the clearing of goods depôts; with results more favourable to the interests of the customers of the railways.

b) The system of daily demurrage charges at an increasing rate in case of the time allowed for loading or unloading being exceeded has been sufficiently proved to warrant its general adoption;

c) It is desirable that when dealing with privately owned wagons, the regulations should be made as uniform as possible.

[385 .517.7]

QUESTION XVI

(Workmen's dwellings),

By FAUSTO LOLLI, special reporter.

The International Railway Association commissioned Mr. A. F. Banks (for America) (1), and ourselves (for other countries) (2) to examine the question of dwellings for railway personnel.

Considerable difference exists between the situation of the United States railways and that of the railways of Europe, from the point of view of the necessity of providing dwellings for the staff.

The situation as regards the United States railway companies is described in the report which Mr. A. F. Banks, president of the Elgin, Joliet and Eastern Railway, had prepared for the Congress which was to have met at Berlin in 1915, which report still holds good as regards the situation in America.

In general, the American railway companies only provide dwellings for the inspection staff who are obliged to live near to the railway, and for station-masters at stations of secondary importance. For the rest, except for certain cases in which dwellings have been built in localities where there was a deficiency of accommodation, and for provisional arrangements made on the occasion of the opening of important new lines or stations in localities removed from centres of population, the companies generally leave the staff to find their own lodging accommodation. Private enterprise has in fact not been slow to take part in the construction of houses in newly-formed centres; on the other hand, the great development of suburban services, and the running of special trains where necessary for the conveyance of officials and workmen to the place of work, make it possible in many cases for the staff to live at a more or less considerable distance from their work.

It may be noted, further, that in the United States the railway companies have not, apart from the exigencies of the service, any special reasons for extending their activity in the construction of houses, either because public opinion is in general hostile to any intervention by public authorities in the private affairs of their employees, or because the spirit of independence which characterises the population of the country leads the workmen and officials to look after their private affairs, including their housing, themselves, rather than seek the help of the companies.

Under these conditions, and considering that wages are sufficiently high to permit employees either to find suitable accommodation or to bear the expense of travelling by suburban trains when they prefer to live at a distance from their work, it may be said that, as regards the Americain railways, the housing problem does not exist in any special degree.

None the less, some companies en-

(1) See *Bulletin of the Internativnal Railway Congress*, July, 1914, p. 595.

(2) See *Bulletin of the International Railway Association*, February 1922, p. 359.

deavour, where necessary, to attract private capital by encouraging individual contractors or building societies to construct houses intended for sale or letting to their employees, without however taking any financial responsibility in such enterprises. The consideration shown by the companies for their employees has been demonstrated more particularly in the form of assistance afforded by them to the railway section of the Young Men's Christian Association, which runs numerous establishments in which unmarried employees, and employees whose work requires them to travel about, can procure board and lodging at reasonable prices.

The greater part of the railway companies of the United States are associated with this institution.

* * *

Conditions are quite different as regards European railways.

Here private enterprise hesitates more before entering into new capital commitments. Further, the employees are generally ready to accept anything that may be done in their interests, whether by the State or by the companies by which they are employed; and when they experience difficulty in finding lodging accommodation they readily accept the assistance of the companies. The result of this has been that on many railways the question of dwellings for the staff has assumed considerable importance, and the action of the companies in this respect has had to be extended, often to a marked extent, even beyond the limits imposed by the mere necessity of lodging employees whom the requirements of the service compel to live on or near the railway. Such has been particularly the case, in recent years, when railway companies have had to become interested in the solution of the housing problem which has been more or less acute in almost all countries as a result of the war.

We give below a summary of the different questions examined in the report, and of the replies of the European and colonial administrations.

We have thought it necessary in this summary to confine ourselves particularly to the European railways, in view of the fact that the colonial railways are subject to special requirements due to the particular geographical conditions.

As regards that part of the report which refers to dwellings for employees who are compelled to live near the railway, it will be remarked that the different companies follow more or less the same rules in the allotment of lodgings, *viz.* to the permanent way inspection staff, and in part to platelayers, that is to say to those employees who have the most direct responsibility for the state of the permanent way; to station staffs, and especially to station-masters, assistant station-masters, and roadside station-masters; and in some cases to foremen and deputy-foremen of locomotive depots.

The proportion of employees at present lodged in railway buildings varies on the different railways from 5 to 17 % of the total staff; it should be noted, however, that many companies have not a sufficient number of dwellings for all the staff who are entitled to be lodged, and that, as a consequence, they grant to a certain number, in lieu of providing lodgings, an allowance to enable such men to live near their work.

But this policy does not completely satisfy the employees; nor does it meet, as it should, the needs of the railway service. On the other hand, if one considers the recent rise in the price of town houses, it will be understood how difficult it is to increase the number of new buildings.

In view of this situation we think it well to draw attention to the measures taken by some companies with a view to reducing that portion of their expenditure attributable to the housing of

their employees, thereby reducing working expenses as a whole.

Thus, for example, the administration of the Belgian State railways has decided to reduce the number of level-crossing gatekeepers, to confine the inspection of the permanent way to the more important parts, and as regards the remainder of the line to rely on the inspection of platelayers as they go to their work. Similar measures have been adopted recently by the Italian State railways who, having decided, with legislative sanction, to abolish attendance at the less dangerous level-crossings and those from which the permanent way is visible for a sufficiently long distance, have been able to dispense with about 5 500 gatekeepers, thereby effecting a saving of 56 million lire on the annual cost of working, and avoiding the necessity of providing new dwellings on many existing lines.

In this connection we may add that as a result of the introduction of the eight-hour day, consideration might be given to the possibility of reducing the number of dwellings for station staffs for whom lodging is at present provided.

Many companies have been compelled to take steps to provide lodgings for employees not included in those grades of the staff who by the nature of their work are obliged to live on or near the railway. Such has been the case, in particular, in localities where private houses were not available, or into which, because of new and important railway extensions, it had been necessary to bring a number of employees which was large in proportion to the lodgings available in the nearest centres of population.

In order to give an idea of the extent of the activities displayed by railway companies in this connection, it will be sufficient to note that at the end of the year 1920, the East Railway Company of France (3 124 miles) owned 2 800 dwellings for the families of this class of employees together with 1 000 rooms for unmarried men, representing altogether a capital of 35 million fr., of which post-war expenditure accounted for 30 millions; the Paris-Lyons-Mediterranean Company (6 086 miles) had spent 22 million fr. on these dwellings; the London & South Western Railway Company (1 105 miles) had 1 850 houses and cottages, of a capital value of about £796 000; the Italian State railways (9 735 miles of normal gauge) owned 4 677 dwellings, representing a capital of 84 500 000 lire.

In view of the increasing number of these tenements, the principal companies have considered it advisable to study types both of small houses and of buildings designed to accommodate several families.

In studying these types the necessity has been borne in mind of varying, within reasonable limits, the number of rooms per dwelling, so as to provide for the accommodation of large families.

On some railways the great majority of these dwellings consist of three rooms, including a kitchen; in other cases preference has been given to dwellings of four, or even five rooms, including a kitchen; the largest dwellings, with rare exceptions, comprise six rooms and a kitchen.

In this connection we would state that we consider it desirable that new dwellings should have at least three rooms, exclusive of the kitchen, *i. e.*, one room for the parents and two for the children of the two sexes. It may be admissible, however, in large groups of dwellings, to have some sets of apartments consisting of two rooms and a kitchen, or even one room and a kitchen, available for families having children of only one sex, or for young married people.

As a general rule the companies assume direct responsibility for the management and maintenance of these houses.

Some companies fix the rent to be charged to the tenants on the basis of the cost of construction and mainten-

ance, and often also in relation to the wages of the employees; in other cases the amounts are fixed on the basis of the average rents payable in the locality for similar classes of private houses.

But whatever rules are followed in the fixing of rents, as the railway companies are generally content to accept a low rate of interest on the capital invested, the rents are lower, often considerably lower, than the rents of private houses.

If this fact is taken into consideration, together with the fact that the houses built by the companies are highly satisfactory from the point of view of comfort and sanitation, it will be realised that the availability of such dwellings is of great benefit to the staff, not only from the economical standpoint, but also as regards the general well-being of their families. It is not, therefore, surprising to find that, at any rate judging by experience in Italy, these houses are greatly sought after by the employees, and that there is a constant demand for the construction of a still larger number.

In this connection we may remark that some companies intend to continue the construction of these houses, but cannot draw up a programme in advance, because their action will necessarily be determined on the one hand by actual requirements, and on the other by the limitations imposed by the present high cost of building in towns.

It is inevitable that the very considerable financial sacrifices which are involved in the construction of new buildings at the present time should somewhat deter railway companies from committing themselves in this direction, especially in cases where, without resorting to the radical solution of building new dwellings where they are lacking, it may be possible to meet the requirements of the service in some other manner.

We would at this point draw special attention to the expedient adopted in certain cases of conveying employees by special trains between their homes and the place of work.

As regards the question whether the running of these special trains is to be preferred to the construction of new dwellings, it may be said that it does not appear possible to arrive at any general conclusion, for if some companies have stated that they consider that from the point of view of economy, the running of special trains is to be recommended, it must be recognised that the problem is one whose solution depends essentially on local conditions, and must be considered from the point of view of the exigencies of the service and of the most efficient use of the staff. All that can be said is that if in certain cases the particular conditions suggest the desirability of continuing the conveyance of employees by special trains, such conditions may become modified in the future, and a reduction in the cost of construction will make it easier to provide new dwellings.

The third part of our report deals with the steps taken by railway companies, particularly recently, to assist employees who desire to build their own houses. This assistance is an instance of the efforts made in different countries to solve the housing problem caused by the war; it cannot, therefore, be considered separately, but must be examined in conjunction with the measures adopted by the higher authorities.

The war produced either a great reduction in or the complete cessation of building activities. Since the termination of the war building has been resumed, but only very slowly, as the high cost of materials and labour deter private individuals from investing in building speculations. The consequence is that the number of new dwellings available is greatly below the demand for them.

In the face of this situation the governments of different countries have decided to encourage the construction of

new dwellings by granting special facilities.

With this object they have formulated special legislation under which private individuals or building societies who propose to build houses can obtain loans on mortgage at a low rate of interest, with long periods of repayment. In certain cases they have granted life annuity subsidies, and in others, where it is a question of new construction, exemption from taxes has been allowed during a certain period.

In some countries all classes of citizens are eligible for these advantages; in others they are confined to the employees of public bodies, including railway employees.

As a result, certain companies have had to act as intermediaries between the State and the staff as regards the formation and management of societies representative of those employees who wish to avail themselves of the facilities granted by this special legislation, and as regards the granting of loans.

But, in certain cases, the companies themselves also act directly in the interests of those employees who desire to avail themselves of the facilities afforded by the various governments to those who wish to build their own houses, whether by undertaking the preparation of plans, or by allowing reduced rates of transport for building materials, or by facilitating the procuring of such materials.

These measures have been greatly appreciated by the staff, as is evident, for example, from the information furnished by the Norwegian State railways. This has also been the experience in Italy, where the administration of the State railways had, up to 31 December 1920, granted to building societies, formed among its own employees, loans to the total value of 275 million lire, a sum which at the present date has been almost doubled. In spite of this, the applications by employees for loans and subsidies have become so numerous that it has been impossible to grant them all.

As regards the method in which the companies lend their assistance in this connection, it may be mentioned that since 1920 the Paris-Orleans Railway Company of France has adopted the principle of encouraging the formation of building societies, the advantages arising from which are reserved to railwaymen; and that the Midi Railway Company has announced its intention of following this example. In England also one of these societies has been formed for the benefit of the staff of the Great Western Railway Company.

When the important steps which some railway companies have taken in the construction of dwellings for their staff and the energy which they display in endeavouring to solve the present housing problem, are considered, it cannot but be recognised that their activity in this respect is not only in the interests of the railway service and of the men themselves, but is at the same time beneficial to the community as a whole; and that, by endeavouring to provide suitable dwellings for their men, the companies also fulfil a mission of an eminently social character, since by improving the conditions of existence of their employees and their families they contribute to their moral welfare.

SECTION V. — LIGHT RAILWAYS.

[625 .617]

QUESTION XVII

(Carriages and wagons for light railways),

By Carlo GAVIRAGHI, reporter.

Mr. Gaviraghi's report deals with the lines of all the companies connected with the International Railway Association. This report does not consist of detailed and precise statistics of the narrow gauge railways, but is rather a review of the general conditions under which these lines are constructed and operated. With this object a list of questions addressed to the various railway companies interested was drawn up as follows :

1. Gauge and length of the line :
   Maximum gradient;
   Minimum radius of curves.

2. Types of carriages give drawings and a description with principal features : dimensions, number of seats, brake system, coupling system, suspension system, wheel arrangement, etc., lighting and heating arrangements.

3. Normal make-up of passenger trains.

4. Type of wagons. Give drawings and description.

5. Normal make-up of mixed trains (passengers and goods).

6. Special wagons for facilitating unloading, transhipping and change of gauge.
Give drawings and a detailed description — Working — Classes of goods transhipped.

The Permanent Commission of the International Railway Association, through the intermediary of its late active and distinguished General Secretary, undertook to send the above list of questions to all the administrations belonging to the following States which we will give in alphabetical order: Argentina, Belgium (Continent and Colonies), Brazil, Chili, Egypt, France (Algeria, Tunisia and Colonies), Great Britain (India and Colonies), Greece, Holland (Continent and Colonies), Italy, Luxemburg, Norway, Roumania, Spain, Sweden, Switzerland and the United States of America.

Among the administrations communicated with, and which have kindly replied, the reporter deals with the following; tramways and standard gauge lines not coming within the scope of this report :

1. The Emiliana Company;
2. The Biella Light Railway System;
3. Venetian Secondary Railway Company;
4. Italian Midi Railway Company;
5. Italian Meridional Secondary Railways;
6. Corleone-San Carlo Railway Company;
7. Sardinian Railways;

(1) See *Bulletin of the International Railway Association*, December 1921, p. 2075.

8. Bordeaux Railways;
9. Toulouse South Western Railway;
10. Beaujolais Railway Company;
11. Alsace and Lorraine Railways;
12. French Midi Railway Company;
13. Algerian State Railways;
14. Viège-Zermatt Railway (Switzerland);
15. Yverdon-Sainte-Croix Railway Company (Switzerland);
16. The Bernina Railway;
17. Belgian National Light Railway Company;
18. Netherlands State Railways;
19. Dutch Indies Railways;
20. Norwegian State Railways;
21. Northern of Spain Railway Company;
22. Prince Henri Railway and Mining Company.

The gauge of the track of the twenty-two administrations named falls into three groups :

3 of 3 ft. 6 in. gauge.
13 of 3 ft. 3 3/8 in. gauge.
6 of 3 ft. 1 3/8 in. gauge.

The total length of the lines here under consideration amounts to 6 472 miles, distributed by countries as follows :

Switzerland	59.7 miles.
Italy	616.4 —
France	2 286.6 —
Holland	172.7 —
Belgium	2 625.9 —
Norway	617.5 —
Spain	54.0 —
Luxemburg	39.1 —
Total	6 472.0 miles.

The report includes a brief summary of the principal particulars which have been supplied in answer to the questionnaire as regards the types of passenger stock and goods wagons, and rolling stock specially constructed to overcome the difficulty of the change of gauge, also the type and normal composition of the trains for regular traffic.

Based on this information, the reporter has arrived at these conclusions :

I. — There is obvious necessity for a Technical Union of Narrow Gauge Railways, as existing in France, Switzerland and Germany, and such as has already been approved by the resolution proposed by Mr. Ottone, and unanimously carried at the third Congress (Florence 1914) of the « Italian Association of Transport and Communication Engineers »;

II. — As regards passenger stock, it is stated that there is an increasing tendency, which is particularly apparent in the most recent examples, to fall into line with standard gauge practice.

Health and comfort go hand-in-hand with modern progress in the construction of passenger carriages, and this applies to all classes, with regard to lighting which, in the latest types is electric — even on railways having steam traction, and is effected (Belgian National Light Railways and Norwegian Railways) by means of dynamos driven from the axles — and with regard to heating which is generally effected by steam by means of heating pipes or radiators.

III. — The same remarks apply to the construction of wagons used for the transport of goods and cattle as to the passenger rolling stock; there is no appreciable difference arising from the fact that the gauge is not the same.

On nearly all the lines under consideration, similar types of wagons are found.

IV. — As regards special wagons to overcome the difficulty of the change of gauge, or more strictly speaking, for

transporting standard gauge rolling stock over narrow gauge lines, the report describes among others the systems in special use on the Biella line of the « Société générale des chemins de fer économiques ».

The Biella Railway System carries the normal-gauge railway wagon over its own narrow-gauge lines (3 ft. 1 3/8 in.) by means of special trucks on the Langbein patent system, fitted with the Westinghouse brake.

After making certain observations on the types of trains running on narrow gauge lines and upon the advantages of narrow gauge railways from a constructional point of view, the reporter makes the three following propositions :

I. — A Technical Union is a necessity for the narrow gauge railways, and legislation should therefore be introduced in Italy to provide for its establishment.

II. — The rolling stock of narrow-gauge railways should, apart from certain exceptional cases, be reduced to a small number of types meeting the whole of the necessary conditions for the lines, which differ by the nature of their traffic and the characteristic features of their construction, in such manner as to allow of manufacture in quantity.

III. — It is necessary to take into account generally, in the case of narrow-gauge railways of some magnitude, the system in use for carrying normal-gauge wagons on these lines and particularly tank-wagons; with this object it will be necessary to make provision for the possibility of the handling and transport of such wagons when working out the projects for new lines.

[625 .272]

QUESTION XVIII

(Operation of light railways; working rules and regulations),

By F. LEVEL, reporter (1).

Mr. C. de Tolnay in his report to the Congress of 1905 expressed himself in the following terms (2):

It is, therefore, very difficult to define what is meant by « lines which carry little traffic »; the definition of what constitutes a « light railway » is not less vague. Sometimes, simple tramways with mechanical traction, hardly 10 kilometres (6 miles 2) long, built on high roads and scarcely capable of carrying any goods traffic, are called light railways; at others, the same name is applied to lines a hundred kilometres (62 miles) in length, carrying the traffic of a whole district. It is, therefore, necessary to decide within what limits the subject is to be confined, and in the opinion of the reporter all lines having clearly the character of tramways, operating more especially passenger traffic, and called *Kleinbahnen* (minor railways), are outside the scope of his report.

On the same subject we will repeat certain passages of Mr. J. Rocca's report also read at the Congress of 1905 (3) :

The words *economic* and *cheap* are perhaps the cause of the suspicion with which the system is regarded, of the obstacles which it encounters; for these words give the idea of something imperfect and lead to the notion that the saving is obtained at the cost of the safety and of the comfort of the public. But this is not so; the whole question is in reality the proper proportioning of the service to the requirements of the line. It would therefore be an advantage if the Congress gave an exact definition of the term « cheap », or « economic ».

We feel that we must share the view of our esteemed predecessors and agree with them as to the advisability of reconsidering the question with a view to fixing on an exact definition so that any administration that is being consulted, especially if it belongs to a country where the expression « Economical Lines » (« Lignes économiques ») is not in use may decide whether or not certain of its lines in operation may be included or not in this category.

It seems to us that the character alone should be considered which gives to secondary lines the light traffic they have to deal with and for which they have been constructed and equipped.

This general statement having been made, we will proceed to point out in following the order of the list of questions, what appears to us to be the chief meaning contained in the replies received, apologising for the dryness of a report on a subject that only discussion

(1) Vide *Bulletin of the International Railway Congress*, number of October 1921, p. 1471.

(2) Vide *Bulletin of the Railway Congress*, February 1905, p. 798, and *Proceedings of the seventh session* (Washington, 1905), vol. 3, p. XIX-50.

(3) Vide *Bulletin of the Railway congress*, December 1904, p. 1884, and *Proceedings of the seventh session* (Washington 1905), vol. 3. p. XIX-48.

at a sessional meeting could apparently render more comprehensive.

QUESTION 1. — *How many classes have you? What kinds of tickets have you: paper, cardboard; pattern? What kind of tickets do you use for weekly tickets?*

In most countries the system of three classes appears to prevail.

All the kinds of tickets in various forms, either in cardboard of the Edmonson type, or of paper, are used in all countries, each administration giving preference to the kind most suitable to its method of operation.

It is difficult therefore to give an opinion on the various kinds which have been considered the most suitable for the nature of the traffic.

Weekly tickets are in use only on very few secondary railway systems.

In France, however, workmen are supplied with them on certain lines.

One kind of ticket which appears to be much used is that of a simple rectangular card taken from a counterfoil book giving particulars of the name of the holder, the length of the journey and available period.

QUESTION 2. — *Do you issue special tickets from all stations to all stations, or have you blank tickets for little-frequented trips? Have you zone tickets? Of what pattern are they? (Please send a specimen.)*

The rectangular cardboard ticket for all destinations in use at important railway stations, and blank tickets for stations to which the traffic is small seem to be most in favour for issuing at booking offices.

On the other hand, paper tickets seem to be generally preferred for distribution on the journey by the conductors, either for passengers who have entered at stopping places unprovided with any kind of attendance, or for all the passengers on those lines which have no booking offices at all.

Zone tickets.

We find only one instance of charging by zone :

This has been supplied to us by he Bergslagen Company of Sweden, which states that it does not issue special zone tickets properly so called, but the prices are fixed according to a zone rating.

This appears to mean that blank tickets are issued for one or several zones and liable to be charged for accordingly.

QUESTION 3. — *Have you reduced-rate tickets? For children (at what age)? Return tickets (for all stations, or only for certain stations; what is the reduction)? Ordinary season tickets, pupils' tickets, workmen's tickets? Excursion tickets for single persons, for parties, for clubs of X persons? Seaside tickets?*

The principle of a reduction for carrying children is admitted and put into practice, in different manners, almost everywhere.

There appear to be very few administrations which do not issue return tickets, but amongst these, where the system exists, a reduction is not always allowed on these tickets.

In case a reduction is allowed, this varies according to the lines from one third to one half in excess of the cost of a single ticket.

Scholars. — From the information to hand it would appear that except in France there is very little tendency in general to make special reductions to scholars in the form of season tickets.

It is rather under the form of excursions for groups of scholars that favour is shewn in certain countries, where these reductions are also made subser-

vient to the number composing these groups, and also to the length of the journey.

Excursions. — Excursions of different clubs and societies are often arranged to be run at reduced rates, but vary so much in importance that it is not possible to enter into details.

In no case do we find an instance of *individual* excursion tickets being issued.

As a general rule the reduced rating as far as excursions are concerned seems only to be applied to clubs conditionally to the number of persons and minimum lengths of the journeys.

It is practically the same method as usually applied to scholars and which we have explained above.

QUESTION 4. — *Have you through tickets with other companies?*

The necessity of issuing through tickets between lines which join one another is so evident, that almost all the administrations endeavour to do this whenever possible.

QUESTION 5. — *How are the tickets issued?*

a) *At booking offices?*
b) *At unattended halts?*
c) *By the conductors (at the start, or on the train)?*
d) *By automatic machines?*

Which of these systems does your experience lead you to prefer?

With the exception of tramways properly so called in which the method of distributing tickets is about general and justified by the multiplicity of stopping places, there are few lines on which tickets are not delivered at the station booking offices. This systems is preferred by the great majority, though it cannot be made quite general on secondary lines where stopping places are often without buildings or attendants.

QUESTION 6. — *How are the tickets collected?*

a) *On arrival at the stations?*
b) *At the unattended halts?*
c) *By the conductors (on arrival. or on the train)?*

On most of the lines provided with stations and properly appointed staffs, that is to say others than tramways, it appears to be the rule to collect the tickets on the arrival at destination by the station employees.

However, a fairly large number of companies make use of another system, by means of which employees charged with the inspection of tickets in the carriages collect them before arrival at destination.

QUESTION 7. — *How are the tickets checked?*

a) *At the stations of departure and of arrival?*
b) *By the conductors on the train?*
c) *By special ticket examiners?*

From the replies received, we find nothing which differs much from the well known methods in common practice concerning the checking of railway tickets and permits.

QUESTION 8. — *In the preceding different cases of checking, how is any excess fare, if any is collected, recorded? In each case, what is the pattern of ticket or of counterfoil issued?*

When tickets are inspected and it is found necessary to charge excess fare, the latter is generally collected then and there by the ticket inspector.

With a view to checking, certain companies also require that the amount of the excess fare should be noted on the train sheet held by the guard.

A receipt is given by the ticket inspector.

There are however lines on which the ticket inspectors are not allowed to give receipts and collect the amounts due.

This is done at the first station the train stops at after the irregularity is noticed.

In certain circumstances, in addition to the excess due, a penalty is imposed (see further on, question 11).

QUESTION 9. — *Are the employees at the stations or on the trains pecuniarily interested in the excess fares, and to what extent?*

The awarding of bonuses to employees charged with the inspection of passenger tickets is pretty generally in vogue.

The per cent of the supplementary charges allotted to the employees varies according to the companies and according to the nature of the regular charges to which they refer; they vary from 5 % (on the South Indian Company Limited) to the whole amount (on the railway from Lausanne to Ouchy).

Sometimes the payment is made to the official in proportion to the supplements collected; other companies divide these latter among the whole of the staff interested.

On the Lausanne-Ouchy railway the receipts from supplements are paid in, in full, to the staff pension fund.

QUESTION 10. — *Are only passengers allowed on the platforms, or do you allow access to others on payment?*

The replies received shew that it is almost the general practive to allow access to the platforms.

It is only in stations of some importance where the number of passengers justifies it, or where the arrangement of the places or size of the staffs permit the entrances to be properly watched that the access to the platforms by others than passengers can be in principle forbidden or only allowed on payment of a small sum.

In many cases access tickets to the platforms are supplied by means of automatic machines.

QUESTION 11. — *Does the legislation of your country enable you to impose a fine on passengers without tickets, and then collect it?*

In most countries the only legal recourse that companies have against travellers in default is to have the infraction declared by a sworn official and this only in cases provided for by the law relating to railway police.

In other countries, where surtaxes are allowed, it seems that the system of immediate repression is the prevailing rule. Many companies apply a surtax equal to the price of the ordinary ticket.

QUESTION 12. — *How is the accounting managed in connexion with the tickets?*

a) *Delivered by the stations?*
b) *Delivered by the collectors?*
c) *Delivered by the employees or outsiders at unattended halts (how are these outsiders remunerated)?*

According to the various administrations, the bookkeeping relating to receipts from tickets issued at stations and in the trains, as well as the excess charges, is either made daily, by periods of several days, or monthly.

It is evidently the importance of the receipts which determines the greater or less frequency of this operation coupled with the necessity of checking irregularities.

The methods in use are generally based on the principle of comparison with the position resulting from the previous audit, so as to bring in evidence on the one hand the number of tickets categorically issued, and on the other the corresponding receipts that may be shewn.

Conclusions.

Amongst the points in evidence in the replies received and to which, in our opinion, the attention of the Congress should be directed, should be placed in the first rank the number of classes offered to passengers.

This number varies from one to three and exceptionally to four classes.

It is certain that there has been an unhappy tendency on the part of Public Authorities to impose on, light, secondary, or lines of local interest the same number of classes which exist on the large systems.

Experience shews that in numerous cases one or two classes at the most would suffice, and it is not necessary to insist on the advantages which would result in the working, especially as concerns the dead load hauled.

Without it being possible to establish a general rule on the subject, it seems that the authorities who have granted the concession might be approached with a view to a favourable consideration of the propositions for a reduction of the number of classes that might be presented by the Concessioners for lines operating in districts where the first class for instance is notoriously most often used by functionaries who have the privilege of free travel.

From another point of view, we think that the Congress might do equally useful work, if, after suitable discussion, it pointed out that necessary powers should be given the companies to fight against the destructive worm represented for them by the traveller without a ticket.

As shewn in the above enquiry, it may be said that it is only exceptionally that companies are able to defend themselves in this respect.

In most cases the ticket inspector can only charge the simple fare, and in defiance of good sense and morality, the passenger, whose obvious intention was to defraud, risks absolutely nothing.

Without doubt it is possible to summon the offender and take him to Court, but this method of repression is in many cases quite onerous and sometimes ineffective. Courts have been known to acquit delinquents of this kind under the plea that the breach was committed on *entering the platform* without a ticket, and it was up to the companies to prevent them so *entering!*

It is therefore very desirable that, following the example of those countries which have already done so, the various Governments should take a special interest in this question and pass the necessary legislative measures so that a fine may be imposed at the time of discovery by a sworn ticket inspector.

From many other points of view the discussion at the sessional meeting of the Congress might be made profitable, either by confining itself closely to the questions under consideration, or else incidentally extending it to connected subjects, the joining together of which forms in fact methods of operation.

If these methods are simple and as much as possible adaptable to local conditions, to the habits of the public, and to the general knowledge of the working staff, it may then be said that they are *economical* and therefore to be recommended.

[625 .616]

QUESTION XIX

(Special methods of traction on light railways),

By P. BIRAGHI, special reporter.

Two reports have been presented on question XIX : « Special methods of traction on light railways », one by Mr. H. B. Spencer for America, and the other by Mr. P. Biraghi for other countries.

The two reporters have very little in the way of development to record in this important branch of the service.

The American reporter informs us that in his country the light railways are of very limited importance and only developed to a slight extent.

The two reporters agree in stating that the lack of enterprise in the introduction of special methods of traction on light railways must be explained by the development of electric traction and of the use of motor cars and motor lorries.

The note by the reporter for countries other than America, which has been written since the war — the American report being dated 1914 — tells us that among other things that the check in progress in this field must also be attributed to the fact, that during the war all available money and technical skill were turned into other channels. In addition to this, the situation is affected by the unfortunate economic conditions that, since the war, have prevailed and are still prevailing in the transport industry, in consequence of the increase in the price of all materials and labour, increases which have not been balanced by a corresponding rise in rates.

The reporter for America deals with three types of special traction in service on the American light railways :

1° The gasoline electric rail car (four cars in service on three lines);

2° Internal combustion rail car (three cars in service on two lines);

3° Steam rail car (two cars in service on one line).

The reporter does not give even a brief description of the above systems, but he gives the characteristics of the lines on which they run, their speed, and their weight which is 45 000 kgr. (100 000 lb.) for the gasolene electric and steam cars, and 29 000 kgr. (65 000 lb.) for the internal combustion cars. He also states that as a rule these rail cars are not coupled to a trailer car.

He gives the working costs for these rail cars compared with those which would obtain with steam locomotives under similar conditions, but the figures are so different between one car and the other of the same system that no definite conclusion can be formed from them, as the reporter himself states in his article.

The reporter of the other countries states that only one of the companies has informed him of a new method of traction, and that consists in coupling a Diesel engine to a dynamo, thus constituting a portable electric power unit, which drives the rail car by two electric motors.

The reporter gives a description in brief outline of the system.

The Diesel electric rail cars are used on lines in Sweden, having characteristics almost comparable to those on which the American rail cars are used, but the Diesel electric cars run at an appreciably higher speed.

The reporter informs us that small trains of 45 000 kgr. (100 000 lb.) are worked by these rail cars, that is 30 000 kgr. (66 500 lb.) for the rail car and 15 000 (33 500 lb.) for the trailer cars.

The only information as regards running that the reporter gives is the cost of fuel. This is 0 fr. 13 per train kilometre and 0 fr. 004 per ton-kilometre.

By comparing these figures with those given by the American reporter for fuel consumption, one can draw up the following table :

Cost of fuel in francs.

RAIL CAR.	Per train-kilometre.	Per ton-kilometre.
Gasoline electric (mean of two cars)	0.21231	0.001680
Petrol (mean of two cars).	0.26641	0.009187
Steam (mean of two cars).	0.07833	0.001741
Diesel electric	0.13000	0.004000

The steam rail car is thus the most economical, but it must be remembered that the figures for the American cars are based on 1914 prices for fuel, while for the Diesel electric car the figure is based on a price of oil at 360 fr. per ton.

From the foregoing we can draw conclusions which go to prove our original opinion, based upon theoretical considerations, and on our practical experience.

The internal combustion engine has properties of which advantage cannot be taken for railway motive power. It develops a large power for a small weight and bulk, but this is not important for railway work, and for this reason, its disadvantages are not compensated for by its advantages.

On the other hand, the steam engine must have, in order to be efficient, a considerable weight and bulk, and when it is necessary to include it in the small space available in a rail car, one must sacrifice efficiency and employ a complex arrangement which entails a high first cost and serious difficulties as regards maintenance.

The most recent solution of the problem, that of having a portable electric power plant, consisting of an internal combustion engine coupled to a dynamo, producing a current which operates electric motors mounted on the axles of the rail car, appears to us to be the most interesting and deserving of further investigation. The high speed Diesel engine appears at the present time to be the best type of internal combustion engine.

We do not mean to imply that the Swedish solution of the problem is perfect, and even if such were the case, it would be necessary to make a closer examination in order to be able to make a definite statement, but certainly it does point out a line of development which should be followed with the greatest interest.

The conclusions arrived at by the two reporters are as follows.

Conclusions of report for America.

1. A reduction in the capital investment which reduces the interest charges seems to be the main economic advantage gained;

2. There is a reduction in the number of employees required under most conditions of the service;

3. The flexibility of the steam service is sacrified. To increase this service for exceptional requirements neces-

sitates usually an increase in the number of trains, as most of the cars do not haul trailers and those that do only carry one, which is ordinarily required for normal service;

4. Frequency of service can be materially improved economically;

5. The demand for this character of service is very limited in the United States principally due to the extensive systems of interurban and suburban railways in operation by electricity;

6. The question of hauling of freight, especially heavy freight, in this character of service should be investigated in order to increase the usefulness of the service;

7. The limited development in this character of service has not been an incentive to develop new methods;

8. The chief development for light railway service has been in the motor car and the only improved methods advanced have been through the motor car;

9. Indications are that the development of light railways will be very limited on account of the development in the motor truck and motor bus.

Conclusions of the reporter for countries other than America.

A. — *Compared with electric traction,* the system has the advantage of avoiding the great expense of the installation on the line, consequently it can be employed with advantage on lines with little intense traffic and on those that are only occupied by trains for a few hours each day.

B. — *Compared with steam traction,* the system offers the following advantages :

1° It avoids the loss of time and the consumption of fuel which are necessary before putting a locomotive into service, the Diesel-electric rail car being able to be got ready at a moment's notice;

2° More efficient use of the fuel;

3° No loss of time in refilling with water and fuel during the journey, even for long runs;

4° Possibility of using water of any quality;

5° Facility of heating and lighting trains;

6° Replacement of the driver and fireman by one operator only.

In reviewing the conclusions stated above, the following observations may be made :

Conclusion No. 1 of the reporter for America becomes clear if one remembers that it refers to a comparison with electric traction, as is stated more clearly by the other reporter in his conclusion A.

Conclusion No. 2 of the reporter for America corresponds to No. 6 of the other reporter.

Conclusion No. 3 of the reporter for America is from one point of view contradictory to his conclusion No. 4. As a matter of fact, flexibility of service is given by the staff being able to dispatch fully loaded vehicles as wished, at longer or shorter intervals, according to the intensity of traffic, but we do not obtain true flexibility if we can only vary the lengths of the trains, while the amount of motive power available remains the same, as this entails an increase or decrease in the efficiency of the tractor.

Conclusion No. 4 should be noted as being very much to the point, and is complimentary to conclusion No. 1 of the other reporter, especially in the case of the Diesel electric rail car, which is capable of hauling two trailer cars. This conclusion (No. 4) should also be enlarged upon by taking into account the development in the passenger traffic which would follow as a natural consequence.

Conclusions Nos. 5, 6, 7 and 9 of the reporter for America concern rather the light railways themselves than special means of traction upon these railways.

Conclusion No. 8 of the reporter for America appears to have special reference to American lines, judging from the development made in light railways without the use of rail cars in other countries.

From the whole report we propose the following

Conclusions.

A. — The system of coupling an internal combustion engine (of which the high speed Diesel is to be preferred at present) to a dynamo, so as to form an electric power plant mounted upon the rail car, ought to be considered, and its development followed with interest.

B. — *Compared with electric traction,* the system has the advantage of avoiding the great expense of the installation on the line, consequently it can be employed with advantage on lines with little intense traffic and on those that are only occupied by trains for a few hours each day.

C. — *Compared with steam traction,* the above mentioned system presents the following advantages :

1° It avoids the loss of time and expenditure of fuel which necessarily precedes putting a locomotive into service, the internal combustion electric rail car being able to be started at a moment's notice;

2° A more frequent service can be economically provided and this will result in a development of passenger traffic;

3. More efficient use of the fuel;

4° No loss of time in refilling with water and fuel during the journey, even for long runs;

5° Possibility of using water of any quality;

6° Facility of heating and lighting trains;

7° Replacement of the driver and fireman by one operator only.

QUESTION XX

(Safety appliances on light railways),

By A. BONNEVIE, special reporter.

Two reports have been drawn up on this question : the first one, by M. S. de Kareischa, for the period ending in 1914 (1); the second one by ourselves, for the period from 1914 to 1921 (2).

Gauge. — About 75 % of the lines are narrow gauge.

Construction. — The majority are constructed, either completely, or for the greater part upon an independent road bed : those in which the track is laid along the public highway, particularly those laid along the side, are generally narrow gauge.

Fences. — These lines are rarely fenced, except on special portions.

Level crossings. — It is very rarely that the level crossings are provided with gates, and still more rarely are they protected or a gatekeeper provided, but as a rule on both sides are placed warning posts, in some cases warning gongs, automatic or otherwise, and in some districts cattle grids.

Motive power. — On the great majority of lines steam locomotives are used. It is only in very exceptional cases, and on very short lines that one man is in charge of an engine. As a rule a driver and fireman are employed, and in some special cases (on colonial lines) there is a second fireman who is a native.

Gradients. — The gradients rarely exceed 30 mm. per m. (1 in 33.3) on the narrow gauge lines, and 20 mm. per m. (1 in 50) on standard gauge lines.

Curves. — The minimum radius used appears to be 30 m. (99 feet) for the narrow gauge, and about 75 m. (246 feet) for the standard gauge.

Curves sharper than the above are found on the electric lines (motors on two axles).

Rails. — The weight of rails varies widely and unaccountably. For new work for usual types of locomotives (9 tons axle load) a rail of about 30 kgr. per metre (60 lb. per yard) appears to be desirable.

Brakes. — On many of the lines, hand brakes (lever or screw) are still the only ones used. The use of a continuous brake tends to become more general, at any rate for the lines through somewhat hilly country. The speed limit of trains on the lines where only hand brakes are used is as a rule about 30 km. per hour (18 1/2 miles per hour), while at least double this is allowed when the continuous brake is used. On most of

(1) See *Bulletin of the International Railway Association*, March 1921, p. 247.

(2) See *Bulletin of the International Railway Association*, October 1921, p. 1539.

the lines only the passenger stock is fitted.

Drawgear. — Automatic couplings are little used, and the semi-automatic are rarer still.

Signals. — Signals are rarely used for protecting the stations, they are as a rule only used at dangerous places, swing bridges, crossings with other lines, etc...

Safety and regularity of working. — To ensure safety and regularity in working, telephones and the telegraph are largely used. On a certain number of lines, various systems of block working, and ordinary or electric pilot staffs and other electrical or semi-electrical devices are in use. On some lines the devices of this nature are as complete as on ordinary railways, especially in the colonies.

In many cases, special regulations give a definite authority to some particular official, allowing him to dispense with these arrangements either wholly or in part.

Points. — As a rule, the principal points are secured by padlocks.

Inspection of track. — The inspection of the track is carried out in the usual way, being performed daily by the ganger, irrespective of periodical inspections by higher officials.

Conclusions.

1. — Laying the track on an independent road bed and placing fencing along the lines in all places where the track crosses the streets of towns or villages, or else laying the track alongside highways.

2. — Putting up at level crossings special posts with warning boards « Beware of the trains ». Providing gates and gatekeepers at crossings where there is much vehicular traffic. Also on certain lines accoustical signals are fixed as reminders at important level crossings in order to ensure safety.

3. — Organizing a track inspection either by foremen or platelayers who must inspect the track at least once a day.

4. — On many railways, providing disc or semaphore signals for protecting the stations.

5. — Authorising on most of the railways a maximum train speed not exceeding 50 km. (31 miles) per hour.

6. — Utilising rolling stock fitted with either hand or continuous brakes for speeds up to 45 km. (28 miles) per hour, and for higher speeds only rolling stock fitted with continuous brakes.

7. — Organizing the running staff so that two men may work each locomotive.

8. — Controlling the train movements by sundry methods so as to prevent collisions or other accidents to the trains. The most common method is by telephone.

The most economic measure for ensuring safety is by limiting the speed to a maximum of 45 to 50 km. (28 to 31 miles) per hour, for this makes it possible to economise in gates and gatekeepers, in signals for protecting the stations, in the use of handbrakes, and in the application of the simplest methods for working the trains.

9. — At sections of the railway that are common to each other, where the danger of meeting or collision is most to be feared, the telephone is in these cases often insufficient for its purpose and it is highly desirable that a means should be found that is certain in action, easy to work and under effective control, at the same time dispensing with, on light railways, the presence of signalmen at fixed posts.

10. — The speed of trains should in general not exceed 10 km. (6.2 miles) per hour where buildings are numerous, and this may in certain cases be reduced to 3.1 miles an hour when streets are thronged.

11. — In case one light railway crosses another, priority must be given « ne varietur » to one or the other.

12. — The necessity of continuous brakes does not only depend on the maximum running speed of the trains, but as much on account of the gradients, especially when these are of some length.

13. — The points giving access to the main line should be locked in a safe and convenient way.

14. — It is advisable to fix safety and catch point interlockings at level crossings on light railways where the importance of the traffic warrants it.

[621 .133 1]

MOTION

(Utility of studying the question of the use of liquid fuel in locomotives),

By Sir HENRY FOWLER, reporter.

The use of liquid fuel for locomotive purposes is extremely local, and its extensive use only obtains in certain parts of the world near the oil fields.

The replies to the questionnaire have been abbreviated and drawn up in tabulated form in appendices A and B.

In view of the abnormal and unstable rates of exchange, no attempt has been made to include the question of costs in the 1920 information.

In 1920 the number of questionnaires sent out was 94, and of this number only 14 administrations had any information which it has been thought necessary to reproduce, and on only 7 administrations was the use of liquid fuel at all extensive.

QUESTION 1 : *System used, cost, etc.* — In all cases the systems used are those which necessitated little or no alterations to the structures of the standard locomotive firebox. The variation of the system consists chiefly of the form and position of the burner and bricking arrangements in the firebox.

The extra cost of fitting apparatus is in no case high. Liquid fuel seems to present no special advantage with any particular type of locomotive. In some cases it is applied for work in tunnels, whilst in other cases the fuel is employed during the summer months in forest regions owing to its freedom from sparks.

One administration used to employ liquid fuel to supplement coal on heavy gradients, but since the introduction of superheated steam this has been found to be unnecessary.

QUESTION 2 : *Type of burner.* — The types of burner divide themselves readily into two classes :

A. — Those in which the oil is allowed to flow through a long narrow slot, and is atomised by steam issuing from a similar narrow slot, either below or approximately on a level with the oil slot.

B. — Those in which the oil issues in a narrow circular orifice, the steam being supplied through a centre cone.

The position of the burners varies, but as a general rule type *A* is placed at the front of the firebox, whilst type *B* is placed at the back.

Type *A* is universal in American practice, whilst type *B* has been almost universal in European practice in the past.

It should also be noted that two administrations have experimented with burners on the « pressure system », *i.e.*, the oil is forced through specially shaped orifices and projected as a fine spray, without the use of any atomising agent. The disadvantages of this system are the liability of the very fine orifices to

(1) See *Bulletin of the International Railway Association*, August 1921, p. 923.

become clogged with carbonised oil or by foreign bodies; and the extra complication of the pumps, etc., necessary to produce the pressure of oil.

Usually one burner only is employed.

QUESTION 3 : *Atomising.* — In all cases steam is used (except in the pressure systems mentioned above). In an interesting communication from the Roumanian State Railways the opinion is expressed that by employing steam direct for atomising, only half as much is used as would be required if it were employed in driving a compressor to supply air for atomising.

QUESTION 4 : *Bricking of firebox.* — As a rule a brick fire pan takes the place of the usual ash pan. Brickwork extends up the sides of the firebox to the level of the brick arch in all cases. No great difficulty seems to be experienced with re-bricking.

QUESTION 5 : *Air Admission.* — The air necessary for the combustion of the fuel is drawn through dampers, there usually being one damper at each end of the firepan. In many cases there are air ducts arranged in the bricking, so that the air may be properly distributed and complete combustion facilitated.

QUESTION 6 : *Alteration of smokebox.* — Very little alteration seems to be necessary to the smokebox.

QUESTION 7 : *Fuel.* — Almost any oil or tar with the necessary physical properties which can be purchased at a reasonably low price is suitable for liquid fuel for locomotives.

The relation that the price of oil bears to the price of coal varies greatly in different countries. Naturally this is the predominating factor in the adoption of oil fuel.

The calorific value is usually in the neightbourhood of 19 000 British thermal units, whilst the flash point is generally 150° Fahr. or above. The figures obtained as to the consumption per train mile and per ton mile vary considerably, this being doubtless due largely to difference of conditions.

QUESTION 8 : *Heating of fuel.* — The practice of heating the oil in the storage tanks on the locomotives by means of steam coils is almost universal. Naturally the amount of heating necessary depends upon the climate. It appears that raising the temperature of the oil to about 100° Fahr. is the most usual practice.

QUESTION 9 : *Method of « Lighting up ».* — Where oil is in general use the method of lighting up is practically always the same, *i. e.*, to utilise either steam or air pressure from a service supply in the shed or from another locomotive to operate the burner.

QUESTION 10 : *Cleaning tubes.* — Some administrations find it necessary to clean the tubes while on the road, and this is generally done when the engine is working heavily by allowing sand to be drawn in through the tubes.

QUESTION 11 : *Particulars of solid fuel used, if any.* — In the majority of cases where liquid fuel is used regularly it is the only fuel employed.

QUESTION 12 : *Arrangements of fuel tanks.* — In American administrations using liquid fuel the tanks for carrying the oil are in most cases built into the tender. In Eastern Europe the oil is usually carried in rectangular or cylindrical tanks.

QUESTION 13 : *Maintenance.* — The question of the effect of the fuel in the firebox is a most important one. Although a number of administrations state that they have no more trouble with oil fuel than with coal, the majority find that the higher temperature reached with

the former method of firing leads to increased trouble.

Questions 14 and 15 : *Steam raising value of fuel.* — Very few experiments seem to have been made to ascertain the steam raising value of the various fuels.

The reporter has carried out several experiments on this subject at various times, and found 1 ton of oil or tar equivalent to 1.8 or 2.0 tons of good coal.

Question 17 : *Noise from burners.* — Generally any noise which the burners make is not sufficient to cause trouble.

Question 18 : *Question of smoke.* — The question of smoke given off when using liquid fuel seems to be entirely one of adjustment. In all cases the best results are obtained with a good clear fire, with just a trace of smoke to ensure that the air is not in excess.

General.

The whole question of liquid fuel for use in producing steam for locomotives narrows itself down to the question of cost. There seems to be no mechanical difficulty whatever in using any class of crude oil or tar which may be available.

The advantages in the use of this fuel are many. Being liquid, although more costly to store, it can be much more readily conveyed to the tender, and from the tender to the point of combustion, than a solid fuel can. For the same reason it can be more readily loaded and unloaded from ships; whilst considerably more calorific value can be carried in the same space and weight.

The regulation of the supply to the firebox is an easy matter, and although requiring perhaps as much attention as solid fuel when on varying gradients, the physical labour is very small. This latter point enters into consideration in some cases where the fireboxes are exceptionally large, and where the labour of firing solid fuel from this cause is great.

Against these advantages, great as they are, must undoubtedly be placed the question of increased expense, except in a few special localities. This expense arises primarily from the cost of the oil incident on its extended use. It must be borne in mind that any extensive use of oil for producing steam in the locomotives of the world would undoubtedly lead to a further increase in price.

In addition to the question of cost of the fuel itself, the question of any increased cost in maintenance has to be considered.

It would seem on the whole that, except in certain neighbourhoods in the vicinity of oil fields and remote from suitable coal, the expense of liquid fuel is too great to render the question of its adoption of practical value.

There is another point with regard to the employment of liquid fuel on locomotives to which the reporter would like to refer, and that is its use in internal combustion engines, in which recent advances have made the employment of heavy crude and cheap oils possible. Lately the question of the construction of internal combustion locomotives of powers comparable with those of ordinary steam locomotives has been considered, and some move has already been made in this direction. The main difficulty has been the question of gears, as the torque of such machines is practically constant, with the result that the locomotives are liable to be slow in starting and on heavy gradients. This matter is one which is receiving considerable attention at the present time, and will doubtless continue to do so, especially in countries where the water supply presents difficulties.

Conclusions.

There are no mechanical difficulties in the adoption and use of liquid fuel for

locomotives. The question of cost both of the fuel and maintenance makes its use, however, prohibitive, except in certain localities, and these are so restricted that the subject is not recommended for discussion by a further Session of the Congress.

The question of the use of liquid fuel in conjunction with internal combustion engines on locomotives is, however, one of more general interest, and might with advantage be considered.

* * *

N. B. — The replies of the Administrations are published in the appendices of this note; they will be found in the *Bulletin of the International Railway Association* for August 1921, p. 935.

SECTION I. — WAY AND WORKS.

[625 .143.2, 625 .15 & 669 .1]

QUESTION III

(Special steels),

By Mr. MESNAGER, special reporter

Three reports have dealt with this question : Report n° 1, by Mr. W. C. Cushing (America) (1); report n° 2 (2) and supplement to this report (3), by the late Mr. Otto Sand (all countries, except France and America; report n° 3, by Mr. Mesnager (France) (4).

Definite results appear to have been obtained with respect to manganese steel. It is stated in Mr. Cushing's report that : « Cast manganese steel has been proved by long experience, under exacting conditions, to be a satisfactory and safe metal for the manufacture of frogs and switch-points, sliding lock bars at draw bridges and many other appliances used on railroads. »

From the information gathered by Mr. Sand, it also appears that several Spanish railways have all their points and crossings made of manganese steel. The Paris-Orleans Railway is following in the same steps. The Paris-Metropolitan Railway and the Paris Omnibus Company are also equally satisfied with their crossings and rails made of cast manganese steel because of the advantages and the obvious economy.

Other special steels have shown superiority in certain cases, but it cannot yet be said of any particular one that competent persons are unanimous as to either the conditions under which they should be used or the special advantages they may possess. The trials are still going on.

It is advisable that the study of this question should be continued, as several special steels may shortly be recognised as being suitable for particular purposes.

Couclusions.

1. — Cast manganese steel with 12 % of manganese and 1.4 % carbon (Hadfield steel) gives excellent results and is economical in crossings on all railways, and its use is tending to become general.

It is specially advantageous in cases where running is slow and traffic heavy over curves of small radii.

2. — Opinions are still divided regarding the use of other special steels. The superiority of any one of them has not been agreed upon unanimously.

3. — Tempering rails has few adherents, and most of the replies are unfavourable to this practice, except in cases where sorbitic structure is required.

4. — It is desirable that research work should be continued in order that the required conditions may be exactly laid down, and improvements made in manufacture, to define the relative value and the circumstances in which the different special steels may be used, together with the conditions which entail taking the various rails out of use.

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(1) See *Bulletin of the International Railway Association*, June 1921, p 557.

(2) See *Bulletin of the International Railway Association*, September 1920, p. 563.

(3) See *Bulletin of the International Railway Association*, August 1921, p. 1103.

(4) See *Bulletin of the International Railway Association*, December 1921, p. 2025.

SECTION II. — LOCOMOTIVES AND ROLLING STOCK.

[621 .33]

QUESTION VIII

(Electric traction),

By Ernest GERARD, special reporter.

A. — General considerations.

1. — In Belgium (1), no section has so far been electrified either on the State Railway System or on those of the ordinary railway companies. Trials have been limited to experiments and to regular running on various lines of six accumulator motor vehicles constructed during the period between 1892 and 1897. Nevertheless, useful information has been obtained relating to the motors, the tractive effort required by the motor vehicles at various speeds, and the appliances for changing and varying the speed.

2. — In all other countries to which the report refers some portion of the railways has been electrified for some time past.

Some countries, such as Italy (2) and Switzerland (3), have respectively merely extended the systems which had given definite results there, in large installations and over a considerable length of time.

The other European countries (4) benefitting by the experience that they have gained on their numerous lines with different systems of electrification, and having carried their enquiries outside their country, have respectively adopted the system most suitable for the local conditions of their railways.

Finally, in the United States (5) which country is still in the forefront for bold experiment in all directions of progress, the question of a standard system has not been put officially.

3. — Instead of finding ourselves, as in the previous sessions, faced with theoretical reports leading to discussions without issue, the Rome Congress will, we hope, be able to draw up conclusions based on actual facts, both from the technical and economic points of view, from the application of systems that have been thoroughly tried and answer to the various needs of the service of great railway systems.

In the appendix will be found a list of electrified lines on the railway systems of general interest.

B. — Production and transmission of energy.

1. — In countries or in districts having large waterfalls, the problem of the production and transmission of the energy intended for the electrification appears to differ from that of other countries.

We find, in fact, in Italy, in Switzer-

(1) See *Bulletin de l'Association internationale des chemins de fer*, février 1922, p. 301.

(2) See *Bulletin of the International Railway Association*, December 1921, p. 2175.

(3) See *Bulletin of the International Railway Association*, October 1921, p. 1357.

(4) See *Bulletin of the International Railway Association*, November 1921, p. 1934, and October 1921, p. 1441.

(5) See *Bulletin of the International Railway Association*, December 1921, p. 2091.

land and in the Scandinavian countries, that the administrations of ordinary railway systems are specially concerned that the energy, from the hydro-electric generating station, shall be supplied under conditions which will allow of its being used, from the conductors running alongside the electrified line for general purposes, as well as for traction on the railway itself.

Central stations, distributed over the Swiss territory, serving the neighbouring railways almost exclusively are producing single-phase current at 15 000 volts of 16.67 periods, supplying the contact wire by the simple means of an aluminium cable suspended alongside the track. Thanks to the reserves formed in the mountains in the shape of natural or artificial lakes, and a system of conductor wires connecting the hydro-electric central generating-stations together these can ensure the motive power and the needs of the electrified Swiss Railways for a long time without making use of coal.

In the North of Italy, the waterfalls and torrents are also turned to account in central generating-stations, where three-phase current of 16.67 periods is produced, at a voltage which depends on the distance to be covered, in order that it may be used after a single reduction of voltage to 3 500 volts on the electrified railways. Nevertheless, these central stations at the same time produce current of the higher periodicities of 42 and 50 periods for all other purposes.

In the Scandinavian countries the hydro-electric generating stations which feed the electrified lines will produce, for their own use, single-phase current at the lower periodicity required by traction motors, but, in view of the great distances to be covered, the primary voltage will be very high and reduced by sub-stations to 16 000 volts.

2. — In other European countries that have formed the subject of reports on Question VIII, particularly England; Belgium, France and Holland, it has not been found desirable to adopt close interdependence between the production of current and its use for electric traction. Moreover, by legal and administrative powers, or by an understanding with the electric industry, attempts are being made to unify the general production of current, under the form of three-phase 50-period current, in order to be able to draw upon this from the different generating stations whatever may be the actual type of current used for traction.

3. — Across the ocean the problem of the generation of electricity does not seem to have caused anxiety to the railway men, who up to the present have generally purchased their current from central stations of large power, which have been built for all purposes, by private enterprise in the region traversed.

C. — **Kind of current. Electric locomotives. Motor vehicles. Technical resultats.**

Types of current adopted. — The reporters are in agreement that the kind of current should be reduced to three types which can be recommended in practice for the electrification of large Railway Systems :

Three-phase at voltages exceeding 3 000 volts;

Single-phase at voltages of 10 000 to 16 000 volts;

Continuous current at 1 500, 2 400 or 3 000 volts.

Their respective advantages and disadvantages have been examined and have been classified as good or bad *intrinsically and extrinsically.*

Intrinsic qualities. — It appears evident that single-phase current at about

15 000 volts is preferred to all other types, for economy in transmission, particularly when, as in Switzerland, it is carried direct in this form from the original source to the contact wire.

The advantage of this diminishes, of course, if, as in Scandinavian countries, the energy must first be carried a great distance at very high voltage, and reduced at sub-stations.

In the North of Italy, where the railway system is relatively fairly compact, three-phase current may be brought to several points at the working voltage of 3 500 volts; but, in general, it is produced at higher voltage and undergoes transformation : the sub-stations are arranged on the average 16 km. (10 miles) apart. Mr. A. Donati raises the question of ascertaining whether it would be possible to reduce the number of sub-stations by increasing the voltage in the contact-wire : in his opinion it would introduce risk of damage to the insulation of the conductors if 5 000 to 5 500 volts were exceeded, although these stand 30 000 volts under test. The double conductor-wire behaves well and its disadvantages are more apparent than real. Its suspension from simple brackets is easier and it is more rapidly installed than the catenary system, and at the same time it is more economical.

3. — It is obvious that continuous current, even at 3 000 volts at the contact-wire, cannot be as economical as the two types of alternating current, for it must always be converted at sub-stations, which are more costly in construction and working than those in which alternating current pure and simple is reduced in voltage by static transformers.

It has, however, the one advantage over the latter, in that it lends itself as well for use with a third rail as with an overhead conductor.

Moreover, the hauling of trains by several locomotives would find increased ease in working and in safety by the use of continuous current, due to the fact that a communication between these electric locomotives can be arranged by means of a weak high-frequency alternating current, using the contact wire which also serves for transmission of the traction current.

4. — With regard to the comparison of the driving motors, theory as well as practise brings out the advantages in favour of the three-phase motor in that it adjusts itself to the working speed and maintains this equally on down-grade or up-grade, under heavy or light loads, and lends itself to automatic regeneration by acting as a brake on down-grades.

It has, however, been found possible, in Switzerland, to give this last property to electric locomotives fitted with single-phase motors.

Moreover, the continuous current equipments also lend themselves to this with the added advantage that they can act as brakes, up to complete stoppage, whereas the three-phase current must be supplemented by the mechanical brake to attain this end.

The total weight of the single-phase motors is about 30 % greater than that of the other two types.

5. — It was, moreover, of primary importance to obtain figures, not only for the specific advantages of the three types of motor, but also for the complete electric equipment carried either on the *electric locomotives* or on the *motor vehicles* as well as the final over-all efficiency of the energy supplied for motive power.

The reports are very incomplete in this respect, although giving tables full of constructive details, in the many appendixes. Moreover, the new figures for efficiency can only be compared with difficulty as they do not relate to the same units. Mr. Donati has shown the method to be followed by referring

his measures of efficiency to the *virtual ton-kilometre.*

With regard to the parts, or groups of parts, to be compared it is advisable, as we have put in evidence in the numerous extracts made from the documents supplied, that these should be chosen according to a set system. We have shown, for example, that it two electric locomotives are compared, only by taking the ratio of total weight to horse-power, they will show quite other differences than if compared by weight, or if compared by the ratio between the electric power and the normal tractive effort.

Finally, owing to the lost work absorbed by the transmission gear or reducing gear of the driving motors, even though the coupling rods and gears should work in a satisfactory manner, it is desirable to have fuller particulars as to the costs of maintenance and of the current they require. The few figures given on this point show the advantages of gearless motors amongst other reasons, because although its use is hardly probable, they are able to use high voltage alternating currents.

Extrinsic qualities. — This is mainly a question of induction and electrolysis due to the traction currents. The precautions necessary for avoiding electrolysis of water-pipes, of gas-pipes, or other metal objects, by the return current through the earth, can easily be taken, more particularly because in the whole of the circuit traversed, any reduction in resistance, or any improvement in the difference of potential between any particular point of the return and the central-station, tends to economy.

It is quite different in the case of the induction effects on weak-current circuits for telephones and telegraphs. The essential figures for the practical results obtained from the three kinds of current under consideration can be compared.

In Italy and in Switzerland it is agreed that the telegraphic and telephonic circuits are not compelled to be carried on or to follow the line of the railway; that in case of electrification the two classes of conductors for powerful and weak currents cause trouble, create dangers of accidental contact and cannot be used together in tunnels or in deep cuttings, so that it is necessary to put the telegraph and telephone wires into lead-covered cables, laid under ground, a precaution that should be taken whatever may be the nature of the traction current.

But this radical precaution, if it were necessary to have recourse to it in some countries, would postpone indefinitely the electrification of the large railway systems, on account of the great expenditure and length of time required for carrying out the necessary work, and for moving, or changing, the enormous quantities of telegraph and telephone wires, the poles for which stand on railway ground.

These considerations have proved a determining factor, in Belgium, as in France, in Great Britain and in Holland, in the selection of high-voltage continuous current between 1 500 and 3 000 volts, apart from the intrinsic qualities mentioned above relating to this type of power-supply.

Moreover, the reporters for these countries explain that a voltage of 1 500 volts will generally suffice, because the railways form closely linked systems, the tracks of which will never be very far from the electric generating stations which will be able to supply the general needs for all purposes.

D.— Financial results Comparison with steam traction.

1. — So few are the financial figures supplied in the reports, and so impossible is it to compare them, that it will be sufficient, in this brief review, to

state that there has been a unanimous wish expressed in favour of the adoption of a standard form of accounts for traction expenses referring the different factors to the same unit.

Nevertheless, it is well to say that Mr. Gibbs, referring to America, does not admit the pecuniary argument, raised in various European countries against the single-phase current, on account of its interference with the telegraphic and telephonic circuits. In the United States, according to him, this question would form the subject of arrangement between those working the railways and the telegraph and telephone companies; moreover, the day will come, he hopes, when technical knowledge will enable these two industries to meet each other's requirements thanks to their respective individual progress.

2. — The economic advantages of electric traction are not, and perhaps will never be, sufficiently evident to justify its universal substitution for steam traction. Moreover the special cases in which it has been adopted are sufficiently well known. The utilisation of « white coal » is a case in point.

3. — Moreover if, in addition to the technical argument put forward, the financial results are such as to prevent general agreement being arrived at for the adoption of one type of current, it might be possible to standardise on a natural basis only. Bearing in mind the example of Italy, electrification might take place, having regard to the general situation, by adopting the system most appropriate, from a general economic standpoint, to the conditions of the railways and districts to be dealt with.

E. — **Conclusion and questionnaire.**

The above general synopsis shows clearly that without wishing to limit the range of questions that will be put at the Congress at Rome on the electrification of the large railway systems, it will be possible this time to direct the discussions of the 2nd section to subjects of practical interest put forward by the reporters.

1. — From the statements of the reporters taken as a whole concerning the relative value of the principal forms of energy applicable to the electrification of railways, we are inclined to conclude that the question « which is the best » will no longer be asked, but rather « under what circumstances should any one of them have preference ».

2. — The point on which all the reporters seem to agree, is the uselessness of standardisation of the current in the contact wire on account of the ease with which locomotives may be changed at the frontiers of the different countries. This question might raise discussions of a political nature which are against the custom of the Railway Congress.

3. — Does the argument, which does not accept as an advantage of the unification of any particular system of electrification on the two sides of a national frontier, apply where the question is one of two districts of the same country, differing geographically, the one mountainous, abounding in waterfalls, the other fairly flat and on the borders of which changes are already being made from steam traction?

4. — It is unanimously desired that the methods of compiling particulars relating to economy should be standardised, not by a system of book-keeping of each electrified group, but what might be called by an *international account.* We hope that a table of comparative *financial particulars will be discussed at a sectional meeting.*

It would be convenient to adopt for this purpose a common standard by which all particulars and results both

technical and financial can be equally measured, for example, *by virtual ton-kilometre which is equivalent to a ton-kilometre on a straight level line.*

Here are a few other questions inspired by the reports :

5. — *Is the longitudinal catenary suspension preferable to the simple transverse suspension, technically and economically?*

6. — *Has the use of three-phase current at 50 periods given rise to practical results justifying its extended use for main line railways?*

7. — *What type of current is the best for use with the Gearless motors, permitting the latter to keep their known advantages?*

8. — *Is multitraction more suitable with one type of current than another?*

It is of course understood that the above questions are only for guidance and are by no means the only ones that might be put.

Steam worked railways of general interest that have been electrified (1).

COUNTRIES.	Continuous current at low pressure: 600 to 850 volts. Kilometres. Double lines.	Continuous current at low pressure: 600 to 850 volts. Kilometres. Single lines.	Continuous current at high pressure: 1 200 to 3 000 volts. Kilometres. Double lines.	Continuous current at high pressure: 1 200 to 3 000 volts. Kilometres. Single lines.	Three-phase current at 3 000 volts, except (c) and (j). Kilometres. Double lines.	Three-phase current at 3 000 volts, except (c) and (j). Kilometres. Single lines.	Single-phase current, 6 000 to 16 000 volts. Kilometres. Double lines.	Single-phase current, 6 000 to 16 000 volts. Kilometres. Single lines	*Remarks.*
Europe.									
France	167	...	31 (a)	...	...	...	24 (b)	...	(a) 2 × 1 200 on two bridges.
Spain	...	...	55	...	22 (c)	...	...	...	(b) In addition Cannes to Grasse, the current is converted into continuous on the locomotive
Great Britain	131	283	43	82	...	...	65	...	
Great Britain (Australia)	...	...	240	...	...	...	...	...	
Italy	60	130	61	...	350	720	142	...	(c) 5 200 volts.
Holland	...	...	...	...	...	...	35	72	
Scandinavia	...	...	...	...	...	...	46 (d)	...	(d) In addition 90 km. under construction.
Switzerland	33 (e)	...	...	...	132 (f)	...	613 (g)	...	
Central countries: Germany	...	...	...	...	...	...	498 (h)	...	(e) In addition 979 km. of secondary lines.
Central countries: Austria and Hungary	...	...	...	...	...	...	141 (i)	...	(f) In addition 46 km. of secondary lines.
America.									
United States	471	1 392	1 371	2 079	10 (j)	...	550	1 949	(g) Of which 222 km. are narrow gauge, Rhaetian Railway.
Canada	...	...	15	37	...	...	...	...	(h) Half of which is in operation.
Brazil	...	...	47	122	...	...	...	...	
Chili	...	...	24	38	...	...	...	...	(i) Of which 91 km. are narrow gauge.
Japan	...	...	30	...	...	...	...	...	(j) A 6 000 volts.
Total	862	...	1 917	...	514	...	2 114	...	
That is to say 5 407 km. of double lines, which amounts to about 11 000 to 12 000 km. of single lines.									

(1) This heading excludes, besides the tramways, railways of local interest, the greater part of which were electrically equipped when constructed.

SECTION III. — WORKING OPERATION.

[656 .253 & 656 .259]

QUESTION XII

(Locomotive cab signals),

By J. VERDEYEN, special reporter.

Question XII has been dealt with in the following reports : that of Mr. Maison (1), inspector general of mines, director of control of the technical working of French railways, which refers to France only and which completed for the period subsequent to 1914 by ourselves (2), and that of Mr. F. Villa (3), chief engineer of the general control of the Italian State Railways, includes all other countries.

The various reporters have confined themselves in their reports to the same headings, and we propose following the same method in this *résumé*.

* * *

An attempt is made with this question to find out the best method of solving two different problems, one being that of repeating the track signals directly on to the locomotive, and the other, that of recording the speed of locomotives.

1st SECTION.

Repeating the signals on engines

After a detailed description of the various apparatus used for repeating the fixed signals on locomotives which have been tried by numerous railway companies interested in this problem so vital for the safety of passengers, the authors have critically examined the replies sent in by the various administrations replying to the questionnaire.

1. — The warning apparatus is not intended to take the place of any of the fixed track signals. As regards this, there is no divergence of opinion; keeping a close watch on the line must always remain the first duty of the engine driver, so as to be able to slacken when necessary at curves and to look out for any obstacles that might unexpectedly occur, etc. The track signals are also only those which can be easily worked by men at fixed points, which allow a mutual control by the traffic staff and those on the trains, thereby greatly increasing safety when running.

Only the Great Western Company in England has discarded, on certain sections of single line working, distant signals in favour of repeating apparatus on the locomotive.

We agree with Mr. Maison that the adoption of repeating signals should not be turned into a new system of signalling with the object of taking the place of that which already exists, but only as an additional safeguard to make it easier to distinguish those already in existence. In no case therefore is it a question of superseding the latter, such an innovation would constitute a great danger, for however perfect the apparatus may be, it will fail sometime, and

(1) See *Bulletin of the International Railway Association*, November 1921 p. 1709.

(2) See *Bulletin of the International Railway Association*, March 1922, p. 537.

(3) This report, having been received too late, will be published further on in the *Bulletin*.

when this happens, there will be nothing on the track to warn the driver of his danger.

2. — In the first place therefore it is necessary to determine which of the track signals should be repeated on the engines. In France this has been definitely decided by the Ministerial circular of the 19 November 1919, which decrees that all the discs and distant signals that may be passed in running should be repeated. As far back as 1914 the French Railway Companies unanimously came to this conclusion, and Mr. Villa is entirely of the same opinion if exclusively limited to a simple repetition of the signals. After having received an indication of the position of the distant signal, the driver will generally have no difficulty in seeing the corresponding home signal or obeying the warnings which have been given to him.

Repeating the position of the distant signal only, also avoids excessive complication and upkeep of the necessary apparatus, which is a very important point as far as smooth working is concerned.

3. — As regards the indications that should be given to the drivers, Mr. Maison concludes from the information furnished to him by the French Railway Companies that the apparatus should be limited to warning the driver that the signal he is approaching is at danger, or even simply in a doubtful position.

Warning given when passing signals showing line clear might have serious inconveniences, for the drivers would get so used to it that their attention would ultimately relax and its value be completely lost. On the other hand, if different kinds of warning signals were given for line clear and line blocked, there would be the fear of line clear being given accidently, either through breakdown, malevolence or other cause, which would be most dangerous.

However, additional knowledge gained since 1914 and furnished by two of the principal French Railway Companies seems to show that it is quite necessary to give the warning when the signal shows line clear. Mr. Villa's report concludes with advancing the same idea. This second indication appears to us quite necessary in order that the apparatus may be kept under proper control. In this case whether the signal shows line clear or line blocked, the apparatus acts, and if a driver passes a signal without any action of the repeating apparatus taking place, he would naturally conclude that the repeating apparatus was at fault and consequently look out for the signals in front as if the engine was not provided with the apparatus. If, however, the apparatus should work at the next signal, he may then assume that it is the track apparatus of the first signal that is out of order and he should in such cases advise the permanent way staff at his first stopping place of the defects which he has noticed.

The discussion which took place at the Berne Railway Congress in 1910 placed in evidence that it is not sufficient to warn a driver that he is approaching a home signal without indicating whether it is on or off, a solution which will always appear incomplete to the general public. We even think that it is the custom, as in Belgium and England (1) especially, to have warning signals giving three indications at a distance (« stop », « caution », or at normal speed up to the corresponding home signal), it is indispensable that these three indications should be given differently to the driver in his cab.

(1) In England there are only two indications, *viz.* : « danger » and « all right », the third « caution » has been abandoned many years. (*Editor's note.*)

4. — The principle of the automatic stop was condemned in France in 1913, and this view is still upheld. This form of apparatus may be at fault owing to the liability of causing serious disturbance in the working of trains, either by abnormal stops brought about by unnecessary action, or even when simply working normally, and thus becomes a source of danger perhaps as grave as that which it is supposed to prevent. The fact is that when passing any distant disc at danger, the train will ultimately have to stop, at least on most railways, this does no apply to the repeater, which only requires a stop being made when the signal it covers is itself at danger. It often happens that between the time the driver has passed the chequer repeater and is arriving at the following stop signal or semaphore, the latter is taken off, and the driver can proceed on his journey. The power to do this could not be possible unless the apparatus was so arranged as to allow the driver to put out of action the automatic braking arrangement. In this case, however, an automatic brake apparatus would be no more than a warning apparatus to the driver and the principle itself would be lost. Of course the driver could not avoid being brought to a stop except by a voluntary action of his own, whilst on the contrary, if the repeating apparatus only gives him a warning, it will be necessary for him to act on his own initiative to put the brake on. On the other hand, if he has a moment of absentmindedness or forgetfulness, in the first case the train would naturally stop, in the second it would proceed towards the obstruction. Whatever the arrangements may be, they are to a certain extent reversible, and from this arises the question whether it would be better to look for an improvement as far as safety is concerned, not only in a guarantee against the momentary absence of mind on the part of the driver when he received a warning signal, but also to guard against the latter not obeying it when he gets it.

It seems therefore that there can be no finality in this line of reasoning if in order to secure safety in working we endeavoured continually to find a protection against any sudden failing of the human element, every action of which is liable to bring about such serious consequences.

As long as it is admitted that a repeating apparatus can automatically work the brake, there is no longer any reason to suppose that it would not also act to give a simple warning in case of a signal at danger. The driver would have received with certainty an indication relative to the position of the signal.

At any rate, this is what may be thought should happen with a warning apparatus that forces attention and consequently it would appear quite improbable to suppose that the driver would not act on the instruction received. The only thing to consider therefore is an involuntary oversight or momentary forgetfulness when in receipt of the communication. It appears quite improbable for such an eventuality to occur, in any case not less than with the various hypotheses that could be advanced relative to danger of accident that might result from errors the driver may make while driving his train.

As far as concerns railway working, it is useless to imagine that absolute safety can be obtained, or that in the desire to obtain it the human element can be dispensed with. It seems therefore the better plan to keep the apparatus as simple as possible and not to interfere with the free action of the driver, whose vigilance must always be the first factor for safety, by the working of an automatic contrivance, more or less perfect, which though appearing to give him every guarantee against danger — because it would necessarily

bring the train to a stop even if the driver disregarded the signals — would quickly give him a false idea of security or lessen his vigilance.

Mr. Villa is absolutely of the same opinion; to sum up, he says, the necessity should be recognised that we guard against the eventuality which happens fairly frequently of the driver missing his signal, and consequently adopt a satisfactory system of repetition, at the same time counting on his observance of the indications that are given to him by its means.

It is precisely for the reason of a possibility on the part of the driver disregarding a warning, and in order to take precautions against this eventuality that certain administrations have adopted automatic action of the brake. This system however does not appear to us to give the absolute security in running which it is desirable to obtain, and at the same time contains all the other inconveniences mentioned above, the most serious of which would be the smaller amount of attention that would be given by the driver to fixed signals.

The results of the trials undertaken on the Italian railways do not point to the advisibility of the automatic application of the brakes. In Belgium, the late Mr. Weissenbruch, who took a special interest in the question of the repetition of fixed track signals on locomotives, only recommended the adoption of a warning apparatus with automatic braking arrangement on those lines of secondary importance which would allow them to be fitted in conjunction with a less perfect signalling system.

5. — The various reporters then deal with the question of the form of warning that should be given to the drivers.

The French are of opinion that this should always be audible. When the distant signal is on, the sound should be loud enough to be heard by others of the train staff as well as by the enginemen. When this signal indicates line clear, it need only be heard by those on the engine.

As the warning is only meant to be additional information to the driver, it is generally considered that a visible indication would be more harmful than useful, because being always under the eyes of the driver, it would become more important to him than the signals along the road. The driver might materially lose interest in the latter and thereby fail to keep a constant look out on the road.

Having pointed out that amongst the railways of the countries to which his enquiry extended, the opinion is not unanimous as regards the form the signal should take, Mr. Villa justifies his preference for the visible method. According to him there is in fact only one alternative; if it is absolutely necessary that the driver should keep a strict eye on the road, the principle of repeating the signals in the cab should not be admitted; if on the other hand the necessity of helping the driver is recognised, and we have already shown that this is irrefutably correct and at the same time of use, this extra assistance should be given as completely and as efficaciously as possible. In the second case we are of opinion that there is nothing more efficacious than placing immediately before the eyes of the driver an optical repetition of the indication given by the signals on the line.

If, as we have shown above, it happens that the driver fails to understand the indications or position of the track signals, what value would be an audible repeating signal to him? This might occur at a time when his attention is absorbed by other duties, perhaps very important ones, which might be dangerous or irregular to neglect, especially if the signals are giving « line clear ». On the other hand, if the signals are at danger, it is evident that the driver's attention should be more markedly call-

ed. With this object in view we think it better to combine the visible and audible methods of repeating with the sole object of immediately drawing the eye of the driver to the repeater, so that when seeing it at danger, he can examine the road himself if it is so possible. From this point of view it results that the audible repetition is an auxiliary to the visible repetition. The latter should in principle have the preference because it appeals to the sense of sight which is without doubt more perfect and developed than the sense of hearing and does not weaken in its acuteness when the driver becomes tired.

We specially call the attention of the members of the 3rd section to this question of first importance, and hope that the discussion will enable us to bring forward the various views that may be advanced on the subject.

The reporters also recommend recording indications given by the warning apparatus. All the French railways, with the exception of the Nord, are of opinion that the position of the signal should be recorded at the time the warning apparatus comes into action, both to fix responsibility in case anything happens and to allow the vigilance of the driver to be controlled; therefore all their apparatus is of the recording type.

The Est and Etat Railways even consider that it is worth while recording signals giving « line clear », this having the advantage of enabling permanent control to be made of the working of the apparatus and also of checking drivers in their look out for signals.

Recording is done with all the various types of apparatus on the speed indicator scroll in use on each company's system, which allows the exact position of each signal to be fixed.

The programme of the Italian State is to allow recording as a subsidiary measure only : arrangements have to be made which easily allow recording indications showing « line clear » or « blocked » on the diagram sheet of the usual tachometers, or else on other diagrams if the locomotives are not fitted with tachometers. In the latter case the paper of the recording apparatus must be unwound proportionally to the distance covered by the driving wheels.

7. — As regards the kind of apparatus which should have preference, this is a question which only seems to have been settled in France, where under pressure of Ministerial instructions, the railway companies have adopted and standardised the electrical type known as « Crocodile » worked with batteries placed on the ground near the signal, so that they may be easily looked after by the men in the signal boxes.

The Midi Company only is trying the possibility of solving the problem of repeating signals by putting into general apparatus carrying detonators. Other countries are still in course of more or less important trials.

Mr. Villa points out the difficulties that are yet to be faced in the solution of this important question, and concludes with the opinion that up to now a perfect system has not yet been found.

We agree with this statement, and at the same time sincerely trust that an early solution of this important problem will be found; we think that for the present it is better to confine attention to improving the track signals by making use of semaphores and lights that give definite indications, and inform the driver by means of distant signals of his direction and pace by adopting the most improved methods. Perhaps the exclusive use of coloured lights by day as well as by night, in place of the usual signal arms and movable discs, would help to this end. For this purpose it would be possible, by making use of electric light, to increase the number of distant signals and so force the driver's attention, by repetition, to the position the home signal is in.

From trials made in America and England, we may hope that this system may prove successful, as it would considerably improve the safe working of trains.

8. — Mr. Maison ends his report with conclusions based on the cab signal trials in France, to which if two amendments were made, we entirely agree. Mr. Villa's conclusions are not very definitely stated.

We suggest to the 3rd section that it adopts the following conclusions which have no other merit than being of a somewhat more general nature than those of Mr. Maison and apply to all the railway systems, instead of exclusively to those in France.

1° In order to avoid passing signals at danger, it is strongly recommended that their visibility be improved by making use of semaphores and lights giving definite indications, and by giving by means of a distant signal an indication to the drivers of the speed they should approach the following home signal (« stop »), « caution » or « line clear ») and to so fix these distant cautioning signals that they may be seen in all weathers, including fog. The use of repeating signals in the driver's cab is also recommended, but this apparatus must only be looked upon in the light of an additional safety appliance for the purpose of making it easier to observe the track signals;

2° The repetition of signals on the engines should be so placed so as not to interfere or weaken the driver's attention, and with this object, the apparatus should record their indications to trace the exact position of the signals when passed, and it is convenient that this should be done on the paper roll of the speed indicators. The warning should be given both for signals showing « line blocked » or « line clear ». Finally it is worth while for safety reasons to check the vigilance of the driver by forcing him, as soon as he perceives a signal at danger, to make some movement which would be recorded;

3° Repeating which position a signal is in should apply specially to distant signals which may be passed in running without warning from any previous signal;

4° Warning should be given to the driver by an audible signal which should be different for each one of the indications of the apparatus. In the case where visible signals are used, it is advisable to make its indications complete by means of an audible signal which acts when the track signal is at danger;

5° It is not advisable for the apparatus to act on the brakes of the train and thus cause an automatic stop even though the driver could prevent this action taking place;

6° By reason of the necessity for registering the position of the signals that have been passed, it is necessary to arrange the track contacts which should put into action the warning and recording appliances when the locomotive runs over them, actually at the signal itself or only a few feet in advance of the signal, in such manner that there may be absolute agreement between the record on the recording strip and the position of the signal seen by the driver at the moment thas he was passing it;

7° The repeating of signals in the cabs of locomotives may be carried out by electrically or mechanically driven apparatus. In France the crocodile type of apparatus is preferred and it is capable of application to single tracks without difficulty. It can also be applied equally well to electrified tracks.

2nd SECTION.

Speed recording.

The problem of speed recording has been settled in France, and the use of it has become current practice on all the large railway systems. The administra-

tions of other countries have as a general rule adopted special recording apparatus or simply speed indicators fixed in the locomotive cab. The only objection made to these instruments was that they were too costly from the point of view of fitting them generally to all the locomotives running on the line as well as for their maintenance and the checking of the recording rolls.

The reports give a short description of the principal kinds in use.

The chief advantages obtained from using this equipement are as follows :

1° Making it possible for the driver to exactly follow his booked working;

2° A greater liberty of action and ease of mind on the part of the driver, who having no longer the anxiety to continually determine the speed of the train by means of his watch or other rough and ready methods so as to keep to time, can give nearly the whole of his attention to working his engine and to looking out for the fixed track signals;

3° Greater safety in working the line for if by chance the driver had exceeded the speed allowed for any particular section and in consequence the train ran at a forbidden or dangerous speed, this would be immediately indicated on the recording apparatus;

4° The possibility of working brakes properly according to indications of the track signals and their repetition in the locomotive cab.

All French Railways are of opinion that the apparatus should at the same time be both indicating and recording. The advantages of the latter are as follows :

5° Irrefutable proof of the responsability of the driver in case of accident produced by excessive speed, or else by too violent or irregular applications of the brakes;

6° The possibility of completely checking by means of the recording diagrams the working of the train almost each instant, thus finding out any error made by the driver.

We propose to the 3rd section to support the conclusions of Mr. Maison relative to this second part of question XII.

These conclusions are as follows :

1° Safety should be the first consideration, and the equipping of all locomotives running on the lines with apparatus which controls the speed can only result in advantage to the railways. To fulfil their object these instruments should be at the same time indicators, that is to say, they should constantly indicate to the driver the speed he is running at, and also recorders, namely, record the working of the train so that it may be possible to reconstruct all the circumstances of the journey;

2° The equipment of nearly all the locomotives on the large French Railways with speed indicating and recording apparatus has already been accomplished, and these instruments work satisfactorily for both purposes;

3° By the use of indicating and recording apparatus, the companies have generally dispensed with fixed apparatus for ascertaining the speed of engines. This however is still useful in certain circumstances when it may be necessary to measure speed with great accuracy, as the indicating and recording apparatus only registers mean speed during a space of 3 to 12 seconds and the space run is only given approximately according to the capabilities of the instrument.

The apparatus is only designed to exercise control by checking the running of trains, and consequently the train and station staffs are in nowise relieved from conforming to all instructions either as regards working or shunting.

SECTION IV. — GENERAL.

[656 .25]

QUESTION XIII

(Net cost. Rates),

By Mr. HENRY-GRÉARD, special reporter.

The question is also stated as follows : *Determination of the costs of transport (passenger and freight) including capital charges. Their relation to rates.*

Three reports have been submitted :

By Mr. Henry-Gréard for European countries excluding German speaking countries, and English speaking countries other than the United States (1);

By Mr. Fairfax Harrison, president of the Southern Railway (2), and by Mr. Samuel O. Dunn (3), for the United States of America.

Mr. Harrison's report deals with a period prior to 1915, while Mr. Dunn's report deals with the subsequent period.

I. — Determination of costs.

The three reports approach the problem in a similar manner : Is it possible to separate from the total working costs the proportion due to the principal classes of traffic in such a way as to be able to draw up a separate balance of receipts and expenses for each of these?

The reports commence by giving a historical summary of the subject, and then deal with the solutions of the problem.

(1) See *Bulletin of the International Railway Association*, February 1922, p. 331.

(2) See *Bulletin of the International Railway Congress*, October 1914, p. 857.

(3) See *Bulletin of the International Railway Association*, January 1922, p. 123.

a) History of the investigations.

These have been very limited as far as Europe is concerned and of an unofficial character. It has never been attempted in Europe to determine traffic costs and to use these as a basis in fixing rates. The only information available is the results of the investigations of a few specialists, or from calculations made on a few railways.

The reporter specially mentions the formulæ proposed by Mr. Amiot at the International Congress of 1889, the conclusions of Mr. Pereire's work on a method of railway accountancy, the comparison made by the Paris-Lyons-Mediterranean between the costs per train-kilometre for fast and slow freight traffic, and the work of Mr. Serani, who worked a unit of value for the costs per axle-kilometre.

These investigate the problem from very different points of view, but have, however, one thing in common, that is their very general character so that they may be applied to any railway system. As regards the uncertainty of these formulæ, this is obvious from the widely different results obtained. The reporter gives examples of this in a comparative table.

To sum up, in the European countries concerned, these investigations have not as yet advanced beyond a very preliminary stage.

The situation is very different in the

United States of America. Right from the beginning they have attempted to ascertain costs on which to base the rates, and for this reason the question has been for many years the object of very careful official investigation. In 1888 the Interstate Commerce Commission instructed the railways to divide the working expenses into two parts, one applying to passenger, and the other to freight traffic. The difficulties, however, of this were at once apparent in practice, at all events as regards certain items, such as the cost of permanent way maintenance, which is not directly dependent on the amount of traffic, and for which there are no very good reasons for adopting one figure rather than another. Thus it was then in 1893 the official statistics ceased to include these particulars.

When, in 1906, the Interstate Commerce Commission, in standardising the method of accountancy, again considered the problem, the same objections, were raised by practical railwaymen against the value of anything which attempted to fix figures for certain expenses having no direct relation to the volume of traffic, and which also varied on different railways. However, the Commission insisted, and on 19 March 1914 sent out to the railways a detailed questionnaire as regards the basic figures suitable for adoption.

After lengthy discussions, the Commission came to a decision and imposed on all the railways, whose annual receipts were greater than one million dollars, rules for the separation of expenses. The application of these rules was suspended during the war, but they again came into force in a slightly modified form in 1920.

Finally, the American Railways have also considered certain problems which are altogether peculiar to themselves. The division of the country into States causes the railways to work under both federal control and that of each individual State, and the accounts of receipts and expenses have had to be drawn up or interpreted differently, according as to whether the particular transport has been effected in one or more States. This has still further added to the complexity of the calculations.

b) **Mode of determining costs.**

In the accounts of nearly all the railways will be found :

1° The working expenses;
2° Establishment charges, that is to say, interest on shares and debentures issued to raise money for the construction of the line, for new plant, or for the purchase of rolling stock, etc.

It is necessary to consider separately these two kinds of expenses.

1° *Working expenses.*

The French report mentions the principal items. It insists on the necessity of submitting these to a detailed examination of which the form and conclusions may and should vary for different lines according to the methods of accounting, and the extent and character of its system. Among these expenses one can quickly pick out :

a) Those which immediately class themselves under one or the other form of traffic;
b) Those which in a more indirect but equally certain manner may be dealt with by means of reference to a sufficient number of concrete cases;
c) Those which in the absence of any data of this kind can only be dealt with by estimate.

The report gives some examples; thus the cost of repairs to passenger coaches or goods wagons can at once be allocated. On the other hand, one cannot, without making special assumptions or calculations, differentiate between the

staff employed in the stations on fast goods traffic, slow traffic, or for general service, but the wages may be allocated to each particular traffic, without appreciable error, according to the proportion of train-kilometres for fast goods or slow goods traffic.

Among the expenses where it is necessary to make an estimate, special mention should be made of that of permanent way maintenance; this may be represented by a formula of the form :

$$V = a + bT$$

where a and b are two constants and T is the traffic.

The mathematical determination, however, of T is different. Among several possible bases, the train-kilometre is preferred by the majority of the railways consulted.

As has been stated elsewhere by the reporter, very few of the railways have undertaken the analytical examination which he suggests. The others have replied to the questionnaire which he sent out, that the method suggested is too uncertain to be worth applying, or else that even if the results were sufficiently dependable, it would entail complex calculations more elaborate than the means at the disposal of the railways would permit.

The American reports, which have the advantage of the considerable practical experience and lengthy investigations made in their country, arrive at very similar conclusions. Mr. Harrison's report specially draws attention to the uncertainty of certain methods of allocating costs and to the different results obtained when these are applied to railways which have very dissimilar physical characteristics. He quotes, for example, the eight assumptions which have been made, all apparently equally justifiable, on the subject of allocating the costs of renewing sleepers.

Mr. Dunn gives a résumé of the scheme finally adopted by the Interstate Commerce Commission in 1916, and subsequently in 1920, for analysing the working costs. These are divided into three categories in the official statistics :

1° Those which can be easily charged to each from of traffic without any error;
2° Those which cannot be dealt with as above but which may be estimated with sufficient accuracy;
3° Those which defy even an approximate analysis of the above kind.

This classification is very similar to that arrived at by the French reporter.

Under the first two categories, the American report includes a number of items. Locomotive maintenance is charged to passenger or freight traffic according to which an engine is used for. For mixed traffic engines, this is done on a basis of engine-miles. The cost of shunting and marshalling are allocated directly as far as possible, and the remainder is divided according to the shunting engine hours for one or the other traffics. The maintenance of telegraph and telephone lines is divided according to the train-mileage, and so on.

In the rules drawn up in 1916, account was taken either by a direct method, or by estimate (as stated in 1 and 2 above) of 82.3 % of the total working expenses. There remains 17.5 % of the expenses of category 3, that is to say, in the « *indivisible* » category. Nearly the whole of this (13.8 %) is represented by the permanent way maintenance. It is always this same point which is the obstacle to a complete analysis.

The 1920 classification attempts to solve this difficulty and bases its allocation of the permanent way maintenance costs on the quantity of coal consumed for the two kinds of traffic. The American reporter considers that this is a reasonable conclusion. The coal consumed is a measure of the power deve-

loped, and this is a function of the weight of the engine, the weight and number of vehicles, and the speed of the train, that is of the various factors which are most likely to have an effect on the line.

With this correction, the rules drawn up in 1920 by the Commission have led to the direct treatment of 100 items of expenses for each traffic (that is 66.6 %) out of the 196 items included in the official statistics; 44 other items are allocated according to estimate, leaving only 52 for which the analysis breaks down. Nevertheless, in order to complete the analysis, it has been decided to distribute these « indivisible expenses » between the two forms of traffic by applying to each a coefficient formed from those of the expenses in the same group of official statistics which can be directly divided.

The Commission itself is far from considering its work as being perfect, and says in conclusion : « The determination of the various factors which affect the cost of permanent way maintenance is a problem which one can hardly hope to solve, in spite of its discussion for twelve years ».

2° *Establishment charges.*

The French report shows that the method of direct analysis can be applied to a large proportion of these charges. The item for the rolling stock can be at once allocated in the case of engines or vehicles specially used for one traffic. It is not difficult for mixed traffic stock to be based on the distances run for each kind of traffic.

There is no greater difficulty in dealing with the additional works which have been carried out, and in splitting up the total amount according to the proportion in which they serve for either traffic.

These methods fail, however, when one is dealing with the cost of the actual construction of the line. Some hypotheses are necessary, and the reporter mentions or criticises a number of these which have been proposed. He considers, for example, that it is not correct to divide up in this way the capital charges according to coefficients found in the division of the working costs. He would be more disposed to trust to a formula based on the gross ton-miles or to one which allocates the charges to each traffic in accordance with its receipts, but he recognises the uncertain character of these suppositions.

In America, the problem presents quite another aspect; it is not merely a matter of technical and statistical interest, but has a legal standing and a direct bearing of the finances of the companies. In accordance with the decrees of the Courts of Justice (the American report quotes these) the railway companies are authorised to receive an equitable net profit on the capital involved on each of the traffics concerned. Being thus obliged to base their rates not only on the working expenses, but also on the proportion of capital involved in each class of traffic they are obliged to accurately determine both : *a*) the amount of this capital, and *b*) the proportion concerned in each kind of traffic.

As regards the first point, it is not sufficient to take the nominal capital. The decision of the Supreme Court is that account is to be taken of the initial cost of the construction of the line and of additional works, of the expenditure which with present day prices of materials would be necessary to carry out the same work, of the market price of the stocks and shares, and the financial state of the railway, etc. With so many factors involved, it will be appreciated how delicate are these estimations of the value of a railway.

The task has, however, been undertaken both by the State Commission and by the Interstate Commerce Commission.

who in 1913 were officially instructed by the Congress to proceed with this work. The work has been in hand since that date, and will probably be terminated this year.

This however is only the first part of the problem. The second part, which is equally necessary in order to adjust the rates, is to definitely allocate the capital value either to the freight or passenger traffic.

Mr. O. Dunn points out that one can commence by excluding certain items which at once fall into one or the other category, such as passenger stations, locomotive sheds specially used for freight engines, etc., but when it is a question of finding a basis on which to deal with items common to both traffics, the same difficulties appear as in the division of the expenses of permanent way maintenance, and the error is much greater in this case, for if the maintenance of the way and works represents scarcely 18 % of the total working expenses, the items common to both traffics amount to at least three quarters of the total capital.

In the latter analysis, Mr. O. Dunn considers that all formulæ for the division of the capital are open to error. In default of any better way, he suggests that it should be done in the same proportion as the relative working expenses.

Mr. Fairfax Harrison has arrived at similar conclusions. He absolutely rejects the idea of being able to divide the capital according to the receipts from each class of traffic. This would be working in a circle, since it is required on the other hand to ascertain for each traffic the net return on the estimated capital. What has to be determined is the degree of utilisation of the capital value of the line by either traffic, that is of its permanent way and equipment; but how is this degree of utilisation to be measured? One cannot compare passenger-miles with ton-miles, these being units having nothing in common. On the other hand (and the reporter lays stress on this point) there are very great differences between the nature of passenger traffic and freight traffic. The variations in the latter immediately effect the ton-miles run, the number of freight trains being diminished when consignments become fewer. It is quite a different matter in the case of passenger traffic where in many cases a booked express train may run almost empty. It cannot then be said that the simple numerical consideration of the units transported is a true measure of the work expended in carrying on either traffic, and this remark holds good if instead of taking the tons, one takes the train-miles.

It is therefore necessary in these calculations to take into consideration the equipment necessary to meet the greatest demand likely to be normally experienced in either class of traffic, and the report concludes that the best basis on which to work is, for freight traffic, the engines and the wagon-miles, and for passenger traffic, the engines and coach-miles.

Both Mr. Harrison and Mr. Dunn also show how difficult the problem is, when in addition to the allocation of capital according to the classes of traffic, distribution has also to be made between local transport (within one State) and Federal transport (through several States). As we have mentioned above, the constitution of the United States and the legal status of their railways has quadrupled the difficulties of the problem.

II. — Practical appliances for costs, statistics.

Within the degree of accuracy recognised, what useful purpose is served by the determination of costs?

The French report reviews the problem. The determination of costs has a

certain value as an indication; though not tallying exactly, it affords a method of appreciating the financial results of the operation in each of the principal classes of traffic when a general increase in receipts is experienced. It assists in determining the most suitable rates to be adopted for each kind of traffic and in deciding upon the difference in the charges to be made for fast and slow traffic. It enables one to determine how the difference in the fares charged for the three classes of passengers corresponds with the difference in working costs which they entail.

The reporter does not consider that anything further should be expected from the determination of costs than what has just been stated. He disagrees with the idea that the rates for each class of traffic can be fixed in this way. There are many reasons against this being done. There is the variation between the physical characteristics of the railways or between the different lines of the same railway, which, with different working expenses, have to apply the same rates by reason of such influences as competition with the canals and the economic needs of the country.

The American reporters share this view. Mr. Harrison calls attention to the effects of competition between the railways and the canals on their rates, and insists on the necessity of uniform rates despite the difference in conditions. Between New York and New Orleans the traffic has the choice between one hundred routes over lines which are widely different as regards gradients and other characteristics. The cost of transport per ton-mile thus varies widely although competition makes it necessary that the public should be required to pay the same rates.

According to Mr. Dunn, the proposal to make the rates an exact function of the costs is an impracticable ideal. A rate is invariable, while the cost is essentially variable. The slow freight traffic is less in May than it is in October, is it proposed then to alter the allocation of capital in May and October? To base the rates on the actual costs is equivalent to considering the capital as a variable quantity.

Finally, Mr. Dunn shows that if it is necessary to make the rates an exact function of the costs, one must exclude the transport of a considerable number of commodities, which cannot pay the actual cost. A ton of sand cannot be charged at the same rate as a ton of silk, which costs the railway the same amount to transport. Should goods of this kind be refused? Suppose, says Mr. Dunn, that the railway accepts sand at a price lower than estimated cost of its transport, including all capital charges, but at such a price that more than cover all the other costs that will be incurred thereby, the result will be that the railway will make a net profit, although it has charged rates below the average cost of transport.

Mr. Dunn also adds : If it were possible on the railways to fix with the greatest accuracy the cost of each form of traffic, the rates should be calculated in such a way :

1° That a traffic which can only pay the « *supplementary* » expenses which it occasions should be charged at rates equivalent to these expenses;

2° That a traffic which can pay the *average* expenses of transport should be charged at rates exactly equivalent to these expenses;

3° That a traffic which can pay rates considerably above the average expenses should be charged at rates corresponding with what it will bear.

We thus arrive at two fundamental rules which are the bases of all methods of fixing rates :

1° The traffic should pay what it can bear;

2° It should pay for all working and establishment charges and leave the railway, on the whole, a margin of profit.

The French report, like that of Mr. Dunn's mentions the question of partial costs, and sees in this topic the most useful contribution to the question of rates.

By reducing or altering the scale of rates, one anticipates an increase in receipts in spite of a reduction in price per unit. Will the new expenses of the traffic be sufficiently covered? This is the most common problem in the practice of fixing or modifying rates. In this case it is not a question of analysing a known total, but of investigating what connection exists between the increase in this expense and the increase in the traffic. This is the distinction often made between the total cost and the partial cost.

The French reporter utters a warning against the danger of making too large an estimate of the partial costs. As a railway seldom works at its full capacity, the effect of an extra amount of traffic is not at once apparent, and there is the risk that considerable error may be made by determining the costs from the expenses which are immediately shown. However, by carrying out the analysis in the same precise manner as for the average costs, it is possible to differentiate between the expenses as follows :

a) Those which are directly proportional to the traffic handled (for example, the expense of motive power);

b) Those which are entirely independent of the traffic;

c) Those which increase with the traffic; but are not directly proportional.

The reporter gives, with some examples, the formulæ which may be used to calculate the partial costs. He does not attempt, however, to determine mathematically the rates that should be adopted, but simply indicates the degrees of magnitude in such a way as to facilitate a study of the problem, and to enable one to estimate the minimum amount of a new form of traffic, when it is necessary to make certain that the arrangements contemplated will not result in certain loss.

The usefulness of these investigations will also become more certain, when, instead of being based on generalities, they have been applied to some well defined concrete cases, such as some particular stream of traffic, or the expenses incurred by running an additional passenger train, etc.

The conclusions which the three reporters submit to the Congress are different in form, but are very similar in all essentials; they are as follows :

Mr. Fairfax Harrison's report : «Under the conditions affecting railway operations in the United States :

« 1° The cost of carriage and the returns upon values used for the aggregate traffic of a railway can be ascertained;

« 2° The cost of carriage and the returns upon values used, by classes, such as interstate freight, intrastate freight, interstate passenger, and intrastate passenger, can be determined with a fair degree of accuracy if not with absolute correctness, but only by the application of formulæ so drawn as to reflect the local and characteristic conditions existing on the individual railway;

« 3° The determination, with any degree of accuracy, of the net profit from an individual rate or a specific group of rates, is an impossibility. »

Mr. Samuel O. Dunn's report : « 1° The method adopted by the Interstate Commerce Commission for separating operating expenses between passenger and freight train service will make it practicable to draw correct general conclusions as to the relative operating costs of freight and passenger train service in the United States;

« 2° No method for allocating property values or capital charges between freight and passenger service has yet been devised which is at all satisfactory. All the allocations of this kind thus far made have been passed on hypotheses which are open to destructive objections.

« 3° Enough of the total operating expenses may be accurately divided between the freight and passenger services, and enough more of them may, with good reason, be assigned to the respective services to make the information obtained useful in determining the relations that should be maintained between freight and passenger rates. Furthermore, enough information may be obtained regarding a large part of the costs of handling mail, express and passengers on passenger trains, and of handling different kinds of freight under similar and differing conditions, to throw light on the way in which the rates for different services should be adjusted. On the other hand, no system of cost accounting can ever be devised which will disclose with even approximate accuracy the total cost, including capital charges of the innumerable individual services rendered by railways in the transportation of freight and passengers; and, furthermore, if these costs were accurately ascertained they could be used only as one among many guides in fixing rates, since it is fundamental that, if the welfare of both the railways and the country are to be furthered by the development of a large traffic, rates always must be based primarily on « what the traffic will bear », having due regard for competitive, economic, industrial and transportation conditions ».

Mr. Henry-Gréard's report : « From the preceding report we may put forward the following conclusions :

« 1° The splitting up of the total working costs and capital charges between the different classes of traffic is possible, assuming that each item of expenditure is analysed, and where necessary examining concrete cases;

« 2° The difficulty of allocating certain costs to each class of traffic, even in these circumstances, prevents the results being absolutely accurate, but permits of information being obtained respecting the relative net proceeds of each traffic;

« 3° The cost price neither is nor can be on any railway the determining factor in making rates, but it is a useful element in the investigations connected therewith. When such investigations are directed to the development of traffic through a modification in rates, in considering the questions, the cost price in relation to the traffic actually carried, should not solely be taken into consideration, but the partial cost price from which the expenses independent of the density of the traffic are excluded. »